Gunshy Manor
Sampling and Quality Assurance Plan
Redmond, Washington

Task Order, Subtask Number: T27-009

October 2019

Prepared for:
United States Environmental Protection Agency
1200 Sixth Avenue
Seattle, Washington 98101

Prepared by:
ECOLOGY AND ENVIRONMENT, INC.
720 Third Avenue, Suite 1700
Seattle, Washington 98104

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Gunshy Manor
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Contract Number: EP-S7-13-07
Task Order, Subtask Number: T27-009

Prepared By:
Jeff Fetters, Project Manager
Ecology and Environment, Inc.
720 Third Avenue, Suite 1700
Seattle, Washington 98104

Submitted To:
Brandon Perkins, Task Monitor
United States Environmental Protection Agency
1200 Sixth Avenue, Suite 155, ECL-13
Seattle, Washington 98101-3123

Date: October 2019

Approvals

Title	Name	Signature	Date
EPA Task Monitor:	Brandon Perkins		
EPA Region 10 Regional Quality Assurance Manager:	Donald M. Brown		
START-IV Team Leader:	Linda Ader		
START-IV Project Manager:	Jeff Fetters		
START-IV Quality Assurance Officer:	Mark Woodke		

SQAP and Final Report Distribution

Name and Title	Organization	E-Mail and Phone Number	SQAP	Final Report
Brandon Perkins, Task Monitor	U.S. Environmental Protection Agency Seattle, Washington	perkins.brandon@epa.gov 206-553-6396	X	X
Myrna Jamison, Project Officer	U.S. Environmental Protection Agency Seattle, Washington	Jamison.myrna@epa.gov 206-553-2931		
Donald M. Brown, Region 10 QAM	U.S. Environmental Protection Agency Seattle, Washington	Brown.DonaldM@epa.gov 206-553-0717	X	
Jennifer Crawford, Region 10 RSCC	U.S. Environmental Protection Agency Seattle, Washington	crawford.jennifer@epa.gov 206-553-6261	X	
Dhroov Shivjiani, Program Manager	Ecology and Environment, Inc. Seattle, Washington	dshivjiani@ene.com 206-624-9537		
Linda Ader, Team Leader	Ecology and Environment, Inc. Seattle, Washington	lader@ene.com 206-406-3411	X	X
Mark Woodke, QA Officer	Ecology and Environment, Inc. Seattle, Washington	mwoodke@ene.com 206-624-9537		
Jeff Fetters, Project Manager	Ecology and Environment, Inc. Seattle, Washington	jfetters@ene.com 206-624-9537	X	X

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List of Abbreviations and Acronyms

Acronym	Definition
bgs	below ground surface
CLP	Contract Laboratory Program
COC	Chain-of-custody
DMP	Data Management Plan
DOH	Washington State Department of Health
DQI	Data Quality Indicator
DQO	Data Quality Objective
E & E	Ecology and Environment, Inc.
Ecology	Washington State Department of Ecology
EDD	Electronic Data Deliverable
EPA	United States Environmental Protection Agency
GIS	Geographic Information System
GPS	Global Positioning System
GWMA	Groundwater Management Area
I-90	Interstate 90
IDW	Investigation-Derived Waste
MEL	Manchester Environmental Laboratory
NPL	National Priorities List
PA	Preliminary Assessment
PCB	Polychlorinated Biphenyl
PM	Project Manager
QA	Quality Assurance
QA/G-5	Guidance for Quality Assurance Project Plans
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
RPD	Relative Percent Difference
RQAM	Regional Quality Assurance Manager
RSCC	Regional Sample Control Coordinator
S4VEM	Stage 4 Validation Electronic and Manual
S4VM	Stage 4 Validation Manual
SMO	Sample Management Office
SOP	Standard Operating Procedure
SOW	Statement of Work
SQAP	Sampling and Quality Assurance Plan
START	Superfund Technical Assessment and Response Team
SVOC	Semivolatile Organic Compound
TDL	Target Distance Limit

List of Abbreviations and Acronyms (cont.)

TM	Task Monitor
TPH	Total Petroleum Hydrocarbons
TPH-Dx	Total Petroleum Hydrocarbons as Diesel
TPH-Gx	Total Petroleum Hydrocarbons as Gasoline
USACE	United States Army Corps of Engineers
VOC	Volatile Organic Compound
WAC	Washington Administrative Code
WGS84	World Geodetic System 1984

1 Project Description

This section defines the objectives and scope for performing a Preliminary Assessment (PA) with limited sampling activities at the Gunshy Manor site. The main goals for the sampling activities are:

- Collect and analyze samples to characterize the potential sources;
- Determine potential for off-site migration of contaminants;
- Provide the United States Environmental Protection Agency (EPA) with adequate information to determine whether the site is eligible for placement on the National Priorities List (NPL); and
- Document a threat or potential threat to public health or the environment posed by the site.

1.1 Problem Definition

Pursuant to EPA Superfund Technical Assessment and Response Team (START)-IV Contract Number EP-S7-13-07 and Task Order, Subtask Number TO-027-009, Ecology and Environment, Inc. (E & E), will perform sampling activities at the Gunshy Manor site, which is located in Redmond, Washington (Figure 1-1). The sampling activities will consist of limited collection of samples at potential contaminant source and target areas for site characterization purposes. This document outlines the technical and analytical approaches E & E will employ during the field work. This document is a combined field operations work plan and site-specific quality assurance project plan (QAPP) for field sampling activities. The combined field operations work plan/QAPP, hereafter called the Sampling and Quality Assurance Plan (SQAP), includes a brief site summary, project objectives, sampling and analytical procedures, and quality assurance (QA) requirements that will be used to obtain valid, representative field samples and measurements. The SQAP is intended to be combined with information presented in E & E's (2013a) *Quality Management Plan* (QMP) for Region 10 START-IV. A copy of the QMP is available in E & E's office at 720 Third Avenue, Suite 1700, Seattle, Washington 98104. This SQAP contains all QAPP elements as described in the EPA *Agency-wide Quality System Document Requirements for QAPPs* (EPA 2001) and *Guidance for Quality Assurance Project Plans* **(**QA/G-5) (EPA 2002). The table of contents, however, reflects a rearrangement of sections for ease of use by the field team.

1.2 Site Background

1.2.1 Site Location

Site Name	Gunshy Manor
SEMS ID Number	WAN001010129
Site Address	7240 196th Avenue Northeast Redmond, Washington 98053
Latitude	47.66958 North
Longitude	-122.07780 West
Legal Description	Township 25 North, Range 6 East, Section 8
County	King
Congressional District	8
Site Owner/Contact	Estate of Barbara J. Nelson 16508 Northeast 79th Street Redmond, Washington 98052

1.2.2 Site Description

Gunshy Manor is the name given to a proposed new residential development on a historic farm in unincorporated King County, Washington, approximately 4 miles east of the Redmond, Washington. The site is accessed via 196th Avenue Northeast. The property is made up of seven parcels (082506-9012, -9013, -9102, -9103, -9104, -9105, and -9067), which total approximately 126 acres (Figure 1-2) that currently contain several large fields, a single-family home, a guest house, a log cabin, and several outbuildings related to former farming operations which include barns, sheds, etc (King County 2019a; ESM 2018). The fields make up the western and central portions of the site, while the northern and southern portions and eastern edge of the site are forested. Topography on the western portion of the site is relatively flat, with elevations increasing near the center of the site and rising steeply on the eastern boundary. Residential properties and developments surround the site to the north, east, and west. Evans Creek runs along a portion of the site's western border and the Evans Creek Natural Area, a large wetland complex, is located south of the western portion of the site (Figure 1-1).

Community members residing near the site have expressed a concern that imported fill material applied to a portion of parcel 082506-9012 known as "Thompson Field" may contain hazardous substances (Figure 1-3) and that if present, these substances may have impacted local groundwater and may represent a cause for concern regarding proposed residential redevelopment plans (Members of Community 2018).

1.2.3 Site Ownership History

In 1890, (b) (6) [redacted] filed a 160-acre land patent claiming the land that includes the subject property and retained ownership of the property until January 1915, when he deeded it to the Dexter Horton Trust and Savings Bank. In June 1926, Dexter Horton National Bank deeded the subject property to (b) (6) [redacted] later conveyed the property to (b) (6) [redacted] by deed recorded August 8, 1940. The guardian of the estate of (b) (6) [redacted] conveyed the property to (b) [redacted] -

(b) (6) by deed recorded December 1, 1952. William and Barbara Nelson purchased the property from (b) (6) in February 4, 1957, and this was the first of the parcels the Nelson family acquired that now make up Gunshy Manor site (ESA 2018). Additional parcels were later purchased, including the parcel known as the Thompson Field in 1975; Double Wide Pasture in 2001; a parcel located south of the Thompson Field in 2011; and, more recently, the Evans Parcel in 2018 located at the north end of the site (Foster Pepper 2018). The property is currently under the ownership of the Estate of Barbra J. Nelson.

1.2.4 Historic and Current Site Operations

The Nelsons operated the Gunshy Manor Farm, where they raised and bred horses and for, some time, cattle. The farm had approximately 40 to 50 acres devoted to horses; however, much of the breeding was conducted off site at other farms. In addition to horse breeding, Gunshy Manor Farm grew hay and pasture grass (ESA 2018).

In order to shed light on the history of development of site features, historic aerial photographs and topographic maps were reviewed. These reviews are discussed in the following sections.

1.2.4.1 Historic Aerial Photographs

Historic aerial photographs that cover all parcels included in the Gunshy Manor site were reviewed for the years 1943, 1965, 1969, 1977, 1980, 1990, 2006, 2009, 2013, and 2017 (Appendix A). Features at the site over these years are described below:

- **1943** – A house and outbuildings are in view in the northwest corner of the western portion of the site along 196th Avenue Southeast, as are fields. What appears to be a second home is in view in the northern portion of the site.
- **1965** – Trees have been cleared from a large portion of the east-central part of the site.
- **1969** – No new changes to the site are evident.
- **1977 -** Additional land has been cleared on the western portion of the site near 196th Avenue Southeast, including land in the Thompson Field area. Two new structures are in view near the center of the site.
- **1980** – Surface conditions appear to be much the same as in 1977.
- **1990** – Additional land has been cleared in the Thompson Field area of the site.
- **2006, 2009, 2013, and 2017** – Surface conditions appear to be much the same as in 1990.

1.2.4.2 Historic Topographic Maps

Historic topographic maps that cover the site were reviewed for the years 1895, 1897, 1950, 1968, 1973, and 2014 (Appendix B). Features at the site over these years are described below:

- **1895 and 1897** – The outline of the site boundaries on these maps has shifted somewhat to the northeast. Elevation lines at the site are in view, as are two structures, one in the northwest portion of the western side of the site along 196th Avenue Southeast and one in the north-central portion of the site.
- **1950, 1968, and 1973** – A clearing in the northwest corner of the western portion of the site and a smaller clearing near the house in the north-central portion of the site are indicated. The remainder of the site is forested. The map from 1968 shows an access road leading from the northern structure and heading south. The map from 1973 shows two new structures on either side of this road near the center of the site.
- **2014** – Most of the western portion of the site has been cleared, as has a large portion of the center of the site.

1.2.5 Previous Investigations

The Seattle District United States Army Corps of Engineers (USACE) performed an inspection of the Gunshy Manor property on March 20, 1984. The inspection report, dated April 3, 1984, indicates that approximately 5,500 cubic yards of earthen fill material was placed in wetlands adjacent to Evans Creek in an effort to create pasture land, and that the work was being completed without a USACE permit (USACE 1984). A letter from the USACE dated April 27, 1984, indicates that an inspection of activities along Evans Creek revealed fill material, approximately 4 feet in depth, placed on wetlands adjacent to waters of the United States, and this work was considered a violation of federal law. On March 26, 1986, the USACE notified the property owners that removal of a portion of the unauthorized fill material was in the public interest (USACE 1986a). A portion of the fill material was removed by the property owners, who were notified on November 5, 1986, by the USACE and November 7, 1986, by King County that their fill removal efforts were satisfactory and no further action was anticipated (USACE 1986b; King County 1986).

On February 18, 2015, staff from the EPA, USACE, the National Oceanic and Atmospheric Administration, and the Washington State Department of Ecology (Ecology) conducted a site visit and collected soil samples at the site; however, details regarding the soil samples collected could not be located for this SQAP. This site visit was conducted in response to heavy earth-moving equipment being used to place fill material into wetlands adjacent to the southern portion of the Thompson Field. This work was conducted on or before January 2010, was not authorized by permit, and was in violation of the Clean Water Act. As a result of the violation, the property owner entered an Administrative Order on Consent, which outlined restoration and mitigation requirements (EPA 2016).

1.2.6 Potential Source Characteristics

It is believed that one source of fill material placed in the Thompson Field in the 1980s was from the Interstate 90 (I-90) expansion project that began in late 1982/early 1983, to complete a large diameter tunnel through the Mount Baker Ridge area, north of the original Mount Baker Tunnel, which was completed in 1940. However, no documents linking the fill material from the I-90 expansion project to the site were available. Some, but not all, of the fill material was later removed; however, the amount removed is not known. Additional fill, related to the EPA Administrative Order on Consent, was placed in the Thompson Field sometime before 2010. The amount and source of this additional fill is not known. Also, anecdotal information suggests that demolition debris from apartment buildings and gas stations was used as fill material at the site at various times from approximately 1957 through the 1980s. However, as noted in Section 1.2.3, the Thompson Field was not acquired by the Nelson Family until 1975 and historic aerial photographs indicate that this area was forested until at least 1969. (Foster Pepper 2018; Members of the Community 2018)

The potential contaminants of concern at the site associated with these operations are total petroleum hydrocarbons (TPH) as diesel (TPH-Dx), TPH as gasoline (TPH-Gx), semivolatile organic compound (SVOCs), polyaromatic hydrocarbons (PAHs), metals including mercury, polychlorinated biphenyl aroclors (PCBs), and volatile organic compounds (VOCs).

1.2.7 Site Visit

A site visit of the Gunshy Manor site was conducted on April 11, 2019. Site visit attendees included:

- Clifford Schmitt, Farallon Consulting;
- Eric LaBrie, ESM Consulting Engineers, LLC;
- Monica Tonel, EPA; and
- Jeff Fetters, E & E.

Upon arriving at the site, the EPA and E & E representatives met with Mr. Schmitt and Mr. La Brie, consultants for the property owner, to discuss the purpose of the investigation and view the site. The primary focus of the site walk was to view the Thompson Field—the area of historic ground-filling activities.

Mr. La Brie indicated that Bill and Barbara Nelson purchased a portion of the site in 1957 and began raising cattle and horses. Cattle operations ceased sometime in the 1980s. The land containing Thompson Field was purchased in 1975, and at that time the property was primarily forested. Mr. Schmitt and Mr. La Brie indicated that material from the I-90 tunnel project was brought to the site for use as fill in leveling the Thompson Field, raising its elevation by approximately 4 feet. The total volume of fill material brought to the site is not known.

The group also viewed the western portion of the property where an irrigation well (Ecology identification number BCB399) is located approximately 1,300 feet east of the Thompson Field. Based on this well's construction log, it was drilled to a depth of 210 feet below ground surface (bgs) and has a static water level of approximately 8 feet bgs. This well is not in use and has had a cap welded to the top of its casing. Mr. La Brie indicated that no other wells were located on the property and that water is supplied to on-site buildings (i.e., primary residence, guest house, and log cabin) via a spring box located on the northeast portion of the property. This spring also provides water to a pond located near the primary residence for fire suppression use.

Before concluding the site visit, the proposed development of the property was briefly discussed. Mr. La Brie and Mr. Schmitt noted that water would be supplied to the development from the Union Hill Water Association. It was also noted that no development is planned for the Thompson Field area.

1.3 Migration/Exposure Pathways and Targets

This subsection discusses the site's environmental setting, groundwater migration pathway, and potential targets within the site's range of influence (see Figure 1 - 4).

1.3.1 Environmental Setting

The Gunshy Manor site is situated within the Puget Lowland physiographic province, a broad, low-lying region bounded by the Olympic Mountains on the west and the Cascade Range on the east. The region's proximity to the Puget Sound and, more so, the Pacific Ocean, supports a maritime climate regime, characterized by moderate temperatures and long-duration precipitation events. Approximately 75% of the annual precipitation occurs from October through March, during which time prevailing winds are from the southwest. Less than 5% of the annual precipitation falls between July and September, and prevailing winds are generally from the northwest. The average annual precipitation for the surrounding area is 42 inches (Redmond 1999).

The topography of the western portion of the property is generally flat, while the central portion gently slopes to the west. Moving east, the property is marked by moderate to steep slopes. Surface water generally flows west across the site to the Evans Creek Natural Area, a large wetland complex that is part of the larger Bear Creek Basin, through which the main stem of Evans Creek flows. Martin Creek, a tributary to Evans Creek, flows west across the northern tip of the site prior to joining Evans Creek. Five other unnamed creeks are located on the property and drain into Evans Creek, which is known to support runs of anadromous fish (Talasaea 2018). These fish include Puget Sound Chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), sockeye (*Oncorhynchus nerka*), steelhead (*Oncorhynchus mykiss*), and coastal cutthroat trout (*Oncorhynchus clarki*) (Talasaea 2018). The Evans Creek Natural Area Site Management Guidelines, published in April 2005 by King County, identifies Evans Creek as the home to substantial populations of Chinook, coho, and sockeye salmon (King County 2005).

The southwest portion of the Thompson Field adjacent to the Evans Creek Natural Area is also classified as wetland and is located within a 100-year floodplain (Talasaea 2018; King County 2005).

Soils in the western portion of the site, in the area of the Thompson Field, consist of Norma sandy loam and Seattle Muck. These soils form in depressions and originate from alluvium and the decomposition of organic material (e.g., sedges, rushes, and grasses), respectively, and are very poorly drained. Near the center and northern portions of the property, Everett very gravely sandy loam and Indianola loamy sand are present. Both these soils form in convex areas from sandy, and sandy and gravelly, glacial outwash and are somewhat excessively drained. Alderwood and Kitsap soils, whose parent material consists of Vashon glacial till and silty lacustrine sediments, respectively, make up the eastern slope of the site and are moderately well-drained (USDA 1973, 2019).

1.3.2 Groundwater Migration Pathway

The target distance limit (TDL) for the groundwater migration pathway is a 4-mile radius that extends from the sources at the site (see Figure 1-4).

1.3.2.1 Geologic Setting

The Puget Lowland was formed by a series of glacial advances and retreats during the Pleistocene epoch. The Puget Lobe of the Cordilleran Ice Sheet advanced into the Puget Lowland at least twice, perhaps four times, during the Pleistocene Epoch depositing. The most recent and final of these glaciations, referred to as the Vashon Stade of the Fraser Glaciation (Vashon), began about 15,000 years ago, when the climate cooled. By 12,500 years ago, the ice had retreated from the Puget Lowland. The ice reached a maximum thickness of 3,000 feet and an elevation of approximately 5,000 feet above mean sea level in King County. This most recent glaciation, however, left behind a characteristic sequence of glacial drift approximately 1,000 feet thick and was the most significant in terms of geologic influence on the development of groundwater in the region. (Redmond 1997, 1999; USGS 1999)

1.3.2.2 Near Site Geology

The Gunshy Manor site lies within the Redmond-Bear Creek Valley Groundwater Management Area (GWMA), which covers an area of approximately 50 square miles bounded by the Snohomish County line on the north, the Bear Creek basin divide on the east, Lake Sammamish on the south, and the Sammamish River on the west. Three basic rock types—tertiary or older sedimentary and crystalline bedrock; semi-consolidated to unconsolidated fluvial, glacial, and marine Pleistocene sediments; and recent alluvium—are found the GWMA, with bedrock being found beneath 400 to 1,200 feet of Pleistocene sediments and recent alluvium. (Redmond 1997, 1999)

Seven individual geologic units have been identified in the GWMA. The units, from youngest to oldest, are as follows:

- Alluvium
- Vashon Recessional Outwash
- Vashon Glacial Till
- Vashon Advance Outwash
- Transitional Beds
- Olympia Gravel
- Older Undifferentiated Deposits

A description of the six youngest units is provided below

Alluvium (Qyal) – Post-glacial depositional and erosional processes have modified the glacial land forms and former stream and river valleys. Today, alluvial sediments are found primarily in the Evans Creek and Bear Creek valleys and in the downtown portion of the city of Redmond, north of Lake Sammamish. The alluvial deposits are composed of organic-rich fine sand, silt, and clay. Their maximum thickness is approximately 40 feet. (Redmond 1997, 1999)

Vashon Recessional Outwash (Qvr) – The Vashon Recessional Outwash consists primarily of permeable, well-drained, stratified sand and gravel with some silt and clay deposited from meltwater emanating from the receding glacier. The Qvr, together with the alluvium described above, make up the unconfined water table aquifer. Locally, the Qvr contains silt, or sand and gravel in a matrix of silt. In areas where the sand and gravel has relatively low silt content, the Qvr facilitates the movement of water, and where a significant amount of silt occurs, the Qvr retards the movement of water. In the GWMA, Qvr deposits range up to 90 feet in thickness and are generally discontinuous, occurring as isolated surface deposits in the Evans Creek Valley. (Redmond 1997, 1999; USGS 1999)

Vashon Till (Qvt) – Commonly known as “hardpan” due to its compacted nature, the Qvt consists of non-sorted clay, silt, sand, gravel, and boulders deposited directly by glacial ice and compacted by the overburden pressure of the overriding Vashon glacier. The Qvt is present at the surface over much of the higher elevations of the GWMA. Due to its dense matrix of silt and clay, the Qvt does not transmit water readily and acts as an aquitard, forming a perched water table and swampy areas lying above it. Thicknesses range up to 100 feet and appear to be thickest in the northern portion of the GWMA. (Redmond 1997, 1999; USGS 1999)

Vashon Advance Outwash (Qva) – The Qva outwash deposits occur below the Qvt and consist of stratified clean sand and gravel with some thin clay beds deposited from melt waters along the perimeter of the Vashon ice sheet as the glacier advanced south into the Puget Sound region. The thickness of this unit ranges up to 90 feet in depth and comprises one of the thickest and most extensive aquifers in the area. Deposits of Qva are exposed on the upper portions of the steep slopes bordering Evans Creek. In the study area, Qva generally underlies the Vashon Till except where it has been eroded away by creeks. (Redmond 1997, 1999; USGS 1999)

Transitional Beds (Qtb) – The Transitional Beds are made up of glacial and non-glacial lacustrine deposits that consist mainly of laminated or thin-bedded to thick-bedded blocky jointed clay, silt, and fine sand, with minor lenses of sand, gravel, peat, and wood. This unit was formed from sediments deposited in shallow lakes and wetlands created by the advancing Vashon Glacier, which covered much of the Puget Lowland between the Olympia Interglacial period and the early Frasier Glaciation. This unit constitutes a major regional aquitard between the Qva aquifer and the underlying deep sand and gravel aquifer of the Olympia Gravel. Where the Qtb consists of a substantial thickness of clay and silt, it serves as a protective layer, retarding the vertical movement of groundwater. The Qtb range up to 180 feet thick and are visible at the surface on the slopes along Evans Creek. (Redmond 1997, 1999; USGS 1999)

Olympia Gravels (Qob) – The Olympia Gravels consist of stratified fine to very coarse sand and gravel with minor thin silt and clay beds deposited by streams. This unit ranges up to 135 feet in thickness and is visible in the GWMA on the lower slopes bordering Lake Sammamish and the Evans Creek Valley. Elsewhere, the Olympia Gravels underlie the transitional beds at elevations ranging from 200 feet above mean sea level to 200 feet below mean sea level. (Redmond 1997, 1999; USGS 1999)

1.3.2.3 Aquifer System

At least four major water-bearing zones are present in the GWMA: the alluvial aquifer, sea level aquifer, local upland aquifer, and regional aquifer. The alluvial aquifer includes recent and older alluvium deposited in and along stream channels. The sea level aquifer consists of the Qob and some older undifferentiated deposits found at elevations near mean sea level. The local upland aquifers are made up of discontinuous Qva deposits and permeable zones within the Qvt. The regional aquifers are composed of the older undifferentiated glacial and interglacial deposits. (Redmond 1997, 1999).

The aquifers described above can be divided into shallow, intermediate, and deep groundwater systems. The Alluvial Aquifer and portions of the shallow Local Upland Aquifer make up the shallow groundwater system. The intermediate groundwater system occurs in the sea level aquifer and deeper portions of the local upland aquifer. Lastly, the deep groundwater system includes the regional aquifers. For the purposes of this SI, only the shallow alluvial aquifer will be further discussed. (Redmond 1997, 1999)

The Alluvial Aquifer appear restricted to alluvial deposits along creeks, including Evans Creek, in the GWMA. These deposits consist of sand, gravel, and silt deposited in and along stream channels as alluvium, alluvial fan deposits, and older alluvium. The Alluvial Aquifer is proximate to the Local Upland Aquifer and the Sea Level Aquifer to either side and underneath, respectively. However, aquitards generally separate the three aquifers. The aquitards Qvt and Qtb separate the Local Upland Aquifer from the Alluvial Aquifer; nevertheless, spring, interflow, and upward discharge from the Local Upland Aquifer may be responsible for considerable but indirect recharge to the Alluvial Aquifer. Generally, the Qtb separates the Sea Level Aquifer from the overlying Alluvial Aquifer, except possibly in lower Evans Creek and near Lake Sammamish. The overall thickness of the entire Qyal/Qvry deposit is typically about 70 feet, but only an average of 30 to 40 feet is highly transmissive. (Redmond 1997, 1999)

Within the GWMA, groundwater recharge occurs through precipitation, overland flow, and infiltration from surface water bodies. It is estimated that the Alluvial Aquifer receives 26 inches of recharge per year, with an average precipitation of 42 inches per year reported; recharge also occurs via discharge from the local Uplands Aquifer. The Alluvial Aquifer is typically under unconfined or semi-confined conditions. In general, groundwater in the Alluvial Aquifer flows toward local discharge points along valley streams, in the Sammamish River, and in Lake Sammamish. Groundwater elevations in the Alluvial Aquifer near Evans Creek fall from approximately 120 feet above mean sea level in the eastern portion of the GWMA to 60 feet above mean sea level near the city of Redmond. Horizontal gradients in the GWMA range from 0.004 feet/foot from north to south and 0.01 feet/foot from east to west. (Redmond 1997, 1999)

1.3.2.4 Drinking Water Targets

Groundwater within the 4-mile TDL is used for municipal and domestic drinking water purposes. The Washington State Department of Health (DOH) maintains records of all active public water systems. Public water systems, regardless of group designation, indicate the total number of wells in the system, number of connections, and total population served. A search of the DOH Sentry Internet database and the King County Source Water Assessment Program database revealed the presence of 13 Group A community water systems and 79 Group B community water systems within the 4-mile TDL (DOH 2019; King County 2019b). Table 1-1 present the groundwater populations by distance ring.

The Washington Administrative Code (WAC) defines the Group A and B designations for community water systems as follows:

- **Group A:** (WAC 246-290) Group A water systems are those with 15 or more service connections, regardless of the number of people on the system; or systems serving an average of 25 or more people per day for 60 or more days within a calendar year, regardless of the number of service connections. Group A water systems do not include systems serving fewer than 15 single-family residences, regardless of the number of people on the system.
- **Group B:** (WAC 246-291) Group B water systems serve less than 15 residential connections and serve less than 25 people per day; or serve 25 or more people per day fewer than 60 days per year. Group B water systems are public water systems that do not meet the definition of a Group A water system.

The City of Redmond provides drinking water for residences from both surface water and groundwater sources. Residences located on the west side of Lake Sammamish and the Sammamish River, as well as those who live in Redmond Ridge and Trilogy developments, are supplied drinking water from the Tolt River Watershed located outside the 4-mile TDL in the Cascade Mountains. Residences located east of Lake Sammamish and the Sammamish River are supplied drinking water from five wells located within the 4-mile TDL. Four of these wells are located 1 to 2 miles from the site, and the other is located 2 to 3 miles from the site. Groundwater from these wells is blended prior to distribution, and no single well provides more than 40% of the total water supply to the system. A total of population of 68,675 people are served by these wells. Based on this information, it is estimated that each well provides 13,735 people with water (i.e., 68,675 people / 5 wells = 13,735 people per well). A total of 54,940 people (i.e., 13,735 people x 4 wells) are served by the four wells located 1 to 2 miles from the site, and a total of 13,735 people are served by the well located 2 to 3 miles from the site. Wellhead protections zones are in place for these wells.

The Union Hill Water Association provides drinking water to residences from three groundwater wells located 2 to 3 miles from the site. A total of population of 4,958 people are served from these wells. The Northeast Sammamish Sewer and Water District supplies drinking water to a total population of 8,161 residences from seven groundwater sources, three of which are located 2 to 3 miles from the site. Groundwater from these wells is blended prior to distribution, and no single well provides more than 40% of the total water supply to the system. Based on this information, it is estimated that each well serves 1,166 people (i.e., 8,161 people / 7 wells = 1,165.86 people per well). The three groundwater wells in this system that are within the 4-mile TDL, therefore, are estimated to serve a population of 3,498 people (i.e., 1,166 people x 3 groundwater wells = 3,498). Wellhead protection zones are in place for these wells. Lastly, the Dawn Breaker Water Association provides drinking water to a total population of 168 residences from two groundwater wells located 3 to 4 miles from the site.

A total of 79 Group B water systems are located within the TDL, serving a total population of 821 people.

Domestic well logs are maintained by Ecology. A search of the internet database revealed the presence of 483 domestic wells (Ecology 2019). The number of people served by each well is not known; therefore, the average number of persons per household for King County, Washington of 2.45 people was used to estimate domestic well populations (USCB 2019). Based on this information, it is calculated that approximately 1,183 people are served by domestic groundwater wells within the 4-mile TDL (i.e., 483 wells x 2.45 people per well). The number of persons served by groundwater wells by distance ring is presented in Table 1-1.

1.4 Areas of Potential Contamination (Sources and Targets)

Sampling for the Gunshy Manor site will be conducted at areas considered potential contamination sources and at areas that may have been contaminated through the migration of Comprehensive Environmental Response, Compensation, and Liability Act–regulated hazardous substances from sources on site. Based on a review of background information and discussions with the EPA Task Monitor (TM) and site representatives, the following areas or features have been identified for inspection at the Gunshy Manor site.

1.4.1 Sources

- **Contaminated Subsurface Soil:** Fill material placed in the Thompson Field in late 1982/1983 was thought to have originated from an expansion of I-90. Additional fill was again placed in the Thompson Field sometime before 2010. Anecdotal information suggests that demolition debris from apartment buildings and gas stations may have been used as fill material at various times from approximately 1957 through the 1980s. The net volume of fill placed on site is not known.

1.4.2 Targets

- **Groundwater:** The primary source of drinking water near the site is from Group A and B community water systems, as well as domestic wells. If soil contamination exists at the site, it may have impacted local groundwater.

1.5 Sampling Process Design

During sampling activities at the Gunshy Manor site, samples will be collected from locations or features that are considered to be potential contamination sources and from potential targets near the site. The locations or features to be sampled have been determined based on information derived from a review of background information and interviews with site representatives. Table 1-2 provides information regarding the sampling design and indicates and whether the measurement is considered critical or noncritical.

At the time of sampling, site-specific conditions (e.g., topography or visual evidence of contamination) will be evaluated and incorporated, when applicable, into the placement of sampling locations. Other conditions that potentially contribute to deviations from the projected sampling locations include new observations or information obtained in the field that warrant an altered sampling approach and difficulty in reaching a desired soil sampling depth caused by high density soil, obstructions, or limited access to a sampling location. E & E will discuss significant deviations from the planned sampling locations or the number of samples to be collected with the EPA TM before implementation. Any deviations will be documented on a Sample Plan Alteration Form (see Appendix C). Every attempt will be made to collect representative samples with the equipment that is on the site.

1.5.1 Sample Locations and Analytical Protocol

Sample locations will be selected to achieve the objectives discussed in Section 1. Samples will be submitted for THP-Dx, TPH-Gx, SVOC/PAHs, Target Analyte List metals, PCB Aroclors, and VOCs analysis. Table 1-3 identifies both environmental and quality control (QC) samples to be collected and analyzed. Figure 1-5 depicts proposed sample locations.

The Gunshy Manor analytical results from the potential source and target areas discussed below will be compared to background samples collected from areas of the site that are not expected to have been affected by site activities. At the direction of the EPA TM, EPA Regional Screening Levels and Washington State Department of Ecology Model Toxics Control Act standards have been provided in Table 1-4 of this SQAP for informational purposes.

Not all identified screening levels and regulatory standards will be achieved due to analytical limitations; however the best available technology will be used for laboratory analysis. Detected results will be reported at the laboratory method detection limit (MDL) and J-qualified as estimated when necessary. See Table 1-4 for a list of target analytes, screening levels, regulatory standards, and expected laboratory reporting limits.

1.5.1.1 Potential Source Locations

Up to five borings are proposed in the area of the Thompson Field where fill material was placed. The borings will be advanced as continuous cores to groundwater, refusal, or 15 feet bgs (whichever is encountered first) in 4-foot sections. Up to three samples will be collected from each of the five borings, for a total of 15 subsurface soil samples. In addition, one groundwater sample will be collected from each of these five borings.

1.5.1.2 Potential Target Locations

Up to three downgradient groundwater samples will be collected to evaluate local groundwater quality. Two of these samples will be collected from monitoring wells owned by the City of Redmond (i.e., monitoring wells MW355 and MW356) that are located at Arthur Anderson Park, and the third sample will be collected from a private monitoring well. All of these wells are located northwest of the Thompson Field. The City of Redmond monitoring wells are both 2 inches in diameter. Well MW355 is 20 feet deep and is screened from 8 to 18 feet bgs. Well MW356 is 20.1 feet deep and is screened from 9.8 to 19.8 feet bgs. The residential monitoring well is a 1-inch-diameter well that is 20 feet deep and is screened from 10 to 20 feet bgs.

1.5.1.3 Background Locations

Background samples will be collected from one boring placed in an area upgradient of the Thompson Field. Background samples will be collected from each matrix where a source and/or target sample is collected (i.e., subsurface soil and groundwater). It is expected that three subsurface soil samples and one groundwater sample will be collected from this boring. All background samples will be analyzed for the same analytes that source and/or target samples were analyzed for. All source and/or target samples will be compared against their respective background sample to determine significant/elevated concentrations. Groundwater samples collected from monitoring and domestic wells will be compared to the background groundwater sample collected from the background boring.

1.5.1.4 Quality Control Samples

Field QC samples will consist of rinsate blanks and trip blanks. Rinsate blank samples will be collected at a rate of 1 per 20 samples collected with non-dedicated equipment. Trip blank samples will be collected at a rate of one per cooler containing samples for volatile analysis. For the Gunshy Manor sampling, it is expected that up to two rinsate samples and two trip blank samples will be collected.

1.5.2 Sampling Methodologies

The START-IV Project Manager (PM) and EPA TM will be responsible for ensuring that appropriate sample collection procedures are followed, and they will take appropriate actions to correct the deficiencies. All samples collected will be maintained under chain-of-custody (COC) and will be stored and shipped in iced coolers.

- **Subsurface Soil Sampling.** Subsurface soil samples will be collected by a Geoprobe™ hydraulic direct-push sampling system. Sampling intervals will be as discussed above. The samples will be collected in dedicated polyvinyl chloride-lined sleeves. The collected material will be placed in a dedicated stainless steel bowl, thoroughly homogenized when applicable, and placed into a pre-labeled sample container. The TPH-Gx and VOC aliquots will be removed from the Geoprobe™ sleeve using 5-gram EnCore ™ samplers (or equivalent) prior to homogenization. These aliquots will be frozen (</= -7 degrees Celsius) in the field to extend the holding time.

- **Temporary Wellpoint Groundwater Sampling.** Groundwater samples will be collected from temporary wellpoints using the Geoprobe™ Screen Point sampling system, dedicated Teflon-lined tubing, and a peristaltic pump. The sampling tubing will be set approximately 1 foot below the water table. The purging pump rate will be set between 0.1 and 0.5 liters per minute, with a goal of limiting the sustained drawdown to a maximum of 4 inches. A decrease in water level greater than 4 inches is allowable as long as the water level stabilizes and remains stable or increases during the remainder of purging and sampling. During the purging process, water quality parameters (pH, temperature, turbidity, oxidation-reduction potential, and conductivity) will be monitored every 5 minutes. Low-flow sampling will commence once water quality parameters have stabilized to the tolerances outlined below:

  ± 0.1 standard unit for pH;

  ± 3% for temperature and specific conductance;

  ± 10% for dissolved oxygen; and

± 10% for turbidity or is less than 10 nephelometric turbidity units.

Samples will be pumped directly into pre-labeled sample containers and preserved as required upon sample collection completion; however, TPH-Gx and VOC sample vials will be preserved prior to sample collection. Sample jars will be filled such that containers requiring a reduced flow rate from the purge rate are collected last (e.g., 40-milliliter vials will be filled last).

- **Monitoring Well Sampling.** Monitoring well samples will be collected in accordance with the groundwater wells standard operating procedure (SOP) for sampling presented in Appendix D. Water level measurements will be taken before monitoring well purging begins. Low-flow purging and sample collection techniques will be utilized to minimize aquifer disturbance and limit the volume of investigation-derived waste (IDW) generated. A peristaltic pump will be used to purge and sample monitoring wells. The sampling pump will be set approximately 1 foot below the water table. The depth of the pump during sampling will be recorded. During the purging process, water quality parameters (pH, temperature, turbidity, oxidation-reduction potential, and conductivity) will be monitored every 5 minutes, as will the water level. The purging pump rate will be set between 0.1 and 0.5 liters per minute, with a goal of limiting the sustained drawdown to a maximum of 4 inches. A decrease in water level greater than 4 inches is allowable as long as the water level stabilizes and remains stable or increases during the remainder of purging and sampling. Low-flow sampling will commence once water quality parameters have stabilized to the tolerances outlined above.

  Samples will be pumped directly into pre-labeled sample containers and preserved as required upon sample collection completion; however, TPH-Gx and VOC sample vials will be preserved prior to sample collection. Sample jars will be filled such that containers requiring a reduced flow rate from the purge rate are collected last (e.g., 40-milliliter vials will be filled last).

1.5.3 Standard Operating Procedures

The START-IV will utilize the SOPs (see Appendix D) while performing field activities:

- Borehole Installation and Subsurface Soil Sampling Methods;
- Collecting Soil and Sediment Samples for VOC Analysis;
- Evaluation of Existing Monitoring Wells;
- Field Activity Logbooks;
- Geologic Logging;
- Geoprobe™ Operation;
- Groundwater Well Sampling;
- Handling Investigation-Derived Wastes;
- Measuring Water Level and Well Depth;

- Procedure for Routine GPS Operation;
- Sampling and Field Equipment Decontamination;
- Sample Handling, Packaging and Shipping; and
- Surface and Shallow Subsurface Soil Sampling.

1.5.4 Sampling Equipment Decontamination

To the greatest extent possible, disposable and/or dedicated personal protective and sampling equipment will be used to avoid cross-contamination. When required, decontamination will be conducted in a central location, upwind and away from suspected contaminant sources. The following decontamination procedures (as listed in Appendix D) will be used for all non-dedicated sampling equipment used to collect routine samples for organic or inorganic constituent analyses:

1. Clean with tap water and nonphosphate detergent, using a brush if necessary to remove particulate matter and surface films. Equipment may be steam cleaned (soap and high-pressure hot water) as an alternative to brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least 2 feet above the floor of the decontamination pad. Polyvinyl chloride or plastic items should not be steam cleaned.
2. Rinse thoroughly with tap water.
3. Air dry the equipment completely.

1.5.5 Global Positioning System

Global positioning system (GPS) units with data loggers will be used to identify the location coordinates of every sample collected, as well as to delineate the boundaries of the potential source areas. GPS coordinates will be provided in the final Gunshy Manor SI report as an appendix and imported to the scribe.net project file. If real-time coordinates cannot be obtained for the site, the START-IV will obtain differential correction data from a local source prior to the start of the survey in order to improve the survey resolution.

1.5.6 Investigation-Derived Waste

The START-IV field team members will make every effort to minimize the generation of IDW throughout the field event. Attempts will be made to evaporate waste water from decontamination operations on site. Any waste water that cannot be evaporated will be contained in 55-gallon drums. Additionally, borehole purge water will be contained in 55-gallon drums. It is expected that up to two 55-gallon drums will be required to contain decontamination and purge water. All IDW drums will be labeled, and disposed of at an approved facility based on analytical results from matrix samples. One composite IDW sample will be collected from the drums of IDW water.

Disposable personal protective clothing and sampling equipment generated during field activities will be rendered unusable by tearing (when appropriate), bagged in opaque plastic garbage bags, and disposed of at the local municipal landfill.

1.6 Coordination with Federal, State, and Local Authorities

The START-IV will keep the EPA TM informed of field event progress and issues that may affect the schedule or outcome of the sampling activities, discuss problems encountered, inform the EPA of any unusual contact with the public or the media, and obtain guidance from the EPA regarding project activities when required. Additionally, the START-IV will notify the EPA Regional Sample Control Coordinator (RSCC) of any changes to the sampling schedule for Manchester Environmental Laboratory (MEL) and/or Contract Laboratory Program (CLP) analyses and will provide shipping information on every sample shipment within 24 hours of shipment or before noon on Friday for Saturday delivery. All samples will be shipped to the laboratory within 24 to 48 hours of sample collection. Further, each Scribe (i.e., the EPA’s data handling software program) CLP .xml COC file will be uploaded to the CLP Sample Management Office (SMO) portal on each day of sample shipment and the project will be published to Scribe.net. The COC .xml and .xls file are provided to the EPA RSCC on the day of shipment along with the usual required notification information (e.g., number of samples per matrix and analysis, date shipped/to arrive, airbill number, project code/case number). The EPA RSCC will pass on the COC .xml to MEL for electronic uploading and checking into their Library Information Management System.

Before initiation of the field activities, the EPA TM or START-IV will provide notification to the property owner, the City of Redmond, and private well owners.

1.7 Logistics

The Gunshy Manor site is accessible by vehicle. Field equipment will be transported to the field via EPA-owned and/or rented vehicles. Property access will be obtained by the EPA.

Sample aliquots collected for fixed laboratory analysis will be delivered to the EPA Region 10 laboratory or an alternative laboratory as directed by the EPA. All fixed laboratory samples will be shipped daily or every other day by commercial airline for express delivery. Sample control and shipping are discussed in Subsection 3.2.

1.8 Schedule

The schedule for implementing the Gunshy Manor sampling event is intended to be used as a guide. Adjustments to the implementation dates and the estimated project duration may be necessary to account for variable unforeseen or unavoidable conditions that the field team may encounter. Examples include inclement weather, difficulties in accessing a sampling site, unforeseen site conditions, or additional time needed to complete a task. Significant schedule changes that arise in the field will be discussed with the TM at the earliest possible opportunity.

The START-IV is targeting October 21 and 22, 2019, to conduct the field work, which is estimated to take two days, including mobilization, demobilization, and all field activities. Samples will be shipped to the analytical laboratory following the field work. Work will be conducted during daylight hours only. The proposed schedule of project work is presented in Table 1-5.

2 Project Management

2.1 Project Task Organization

This subsection outlines the individuals directly involved with the Gunshy Manor sampling and their specific responsibilities. Communication lines are shown on the project's organization chart (see Figure 2-1).

2.1.1 EPA Region 10 Task Monitor

The EPA TM is the decision maker and overall coordinator for the project. The TM reviews and approves the site-specific SQAP and subsequent revisions in terms of project scope, objectives, and schedules. The TM ensures site-specific SQAP implementation, serves as the primary point of contact for project-related problem resolution, and has approving authority for the project.

2.1.2 EPA Region 10 Regional Quality Assurance Manager

The EPA Regional Quality Assurance Manager (RQAM) or designee reviews and approves the site-specific SQAP and revisions in terms of QA aspects. The RQAM or designee may conduct assessments of field activities.

2.1.3 EPA Region 10 Regional Sample Control Coordinator

The EPA RSCC coordinates sample analyses performed through the EPA CLP, the EPA Region 10 MEL, or both. The RSCC also provides sample identification numbers along with a Region 10 project code. The RSCC is the project's EPA Scribe/data management point of contact and reviews all EPA Region 10 Scribe deliverables for adherence to the EPA Region 10 *Data Management Plan* (DMP) (EPA 2014a).

2.1.4 E & E START-IV Site Assessment Team Leader

The E & E START-IV Team Leader provides for the overall coordination of all START-IV Site Assessment projects, ensuring that the projects are technically consistent, accurate, and conform to the overall goals of the EPA Site Assessment Program.

The Site Assessment Team Leader is the EPA's point of contact for all Site Assessment program questions and the alternative point of contact for all Site Assessment projects.

2.1.5 E & E START-IV Project Manager

The E & E START-IV PM provides overall coordination of fieldwork and provides oversight during the preparation of the site-specific SQAP. The PM implements the final approved version of the site-specific SQAP and records any deviations from the plan. The PM acts as the Scribe file manager, is the EPA's primary point of contact for technical problems, and is responsible for the execution of decisions and courses of action deemed appropriate by the TM. In the absence of the project's PM, another E & E PM, or the Team Leader, will assume the PM's responsibilities.

2.1.6 E & E START-IV Quality Assurance Officer

The E & E Quality Assurance Officer (QAO) reviews and approves the site-specific SQAP, conducts in-house audits of field operations, and is responsible for auditing and reviewing the field activities and final deliverables and proposing corrective action for nonconformities, if necessary.

2.1.7 E & E START-IV Analytical Coordinator

The E & E START-IV Analytical Coordinator receives the CLP/EPA Region 10 laboratory information from the EPA RSCC. The Analytical Coordinator also receives validated data from the EPA chemists.

2.1.8 EPA Project Officer and E & E START-IV Program Manager

The EPA Project Officer is responsible for coordinating resources requested by the TM for this project and for the overall execution of the START-IV program.

The START-IV Program Manager is responsible for the overall management of E & E resources for the START-IV contract.

2.2 Quality Objectives and Criteria for Measurement Data

The project data quality objectives (DQOs) for the Gunshy Manor sampling are to: 1) to acquire data that can be reliably used to make decisions regarding the potential release and presence of on-site contamination related to former operations by comparing samples collected from potential source areas to samples collected from backgrounds areas; 2) to characterize potential sources of contamination; 3) determine off-site migration of contaminants through the analysis of groundwater samples; 4) determine whether the site is eligible for placement on the NPL; and 5) document any threats or potential threats that the site poses to public health or the environment. To obtain data that will support this decision, valid data of known and documented quality must be provided and the following quality controls will be applied.

- Laboratories will provide definitive data. The data will be reviewed and assessed for the six data assessment parameters described in Subsections 2.2.2.1 through 2.2.2.6. Field QC samples will include a trip blank(s), rinsate blank(s), and temperature blank(s). Field and laboratory QC will be evaluated, including equipment rinsate blanks, laboratory surrogates, laboratory spikes and duplicates, and laboratory blanks.

- Field QC samples (trip blanks and rinsate blanks) will be collected and analyzed in the same manner as all environmental samples (see Subsection 1.5.1.4).
- Laboratory QC samples (blanks, duplicates, and matrix spikes) will be analyzed to assess laboratory performance (see Subsection 3.6).

The final validated data for the project will be used by the EPA to achieve project objectives. Required laboratory reporting limits for meeting the regulatory criteria values (presented in Table 1-4) are indicated in Table 1-3. Other than for NPL placement, the data may be compared to the regulatory criteria values and screening levels presented in Table 1-4, possibly by the EPA TM as a separate effort from this PA.

The DQO process applied to this project follows that described in the document *Guidance on Systemic Planning Using the Data Quality Objectives Process QA*/G-4 (EPA 2006). See Subsection 3.6 for a detailed discussion of measurement criteria.

2.2.1 Data Quality Objective Data Categories

All samples collected under this SQAP will be analyzed using definitive analytical methods. This project will only use definitive analytical methods that have been approved by the EPA. The data generated under this project will comply with the requirements for this data category as defined in *Data Quality Objectives Process for Superfund Interim Final Guidance* (EPA 1993).

2.2.2 Data Quality Indicators

The goals of data quality indicators (DQIs) representativeness, comparability, completeness, precision, and accuracy for this project were developed following guidelines presented in the EPA’s *Guidance for Quality Assurance Project Plans, EPA QA/G-5* (EPA 2002).

The basis for assessing each element of data quality is discussed in the following subsections. Section 3.6 presents the QA objectives for measurement of analytical data and QC guidelines for precision and accuracy. Other DQI goals are included in the individual SOPs in Appendix D and in the specified analytical methods or Laboratory Statement of Work (SOW).

2.2.2.1 Representativeness

Representativeness is a measure of the degree to which data accurately and precisely represent a population, including a sampling point, a process condition, or an environmental condition. Representativeness is the qualitative term that should be evaluated to determine that measurements are made and physical samples are collected at locations in a manner resulting in characterizing a matrix or medium. Subsequently, representativeness is used to ensure that a sampled population represents the target population and an aliquot represents a sampling unit. This SQAP will be implemented to establish representativeness for this project. Further, all sampling procedures detailed in the SQAP will be followed to ensure that the data are representative of the media sampled. The SQAP describes the sample location, sample collection, and handling techniques that will be used to avoid contamination or compromising of sample integrity and to ensure proper COC of samples. Additionally, the sampling design presented in the SQAP will ensure a sufficient number of samples and level of confidence that analysis of these samples will detect any chemicals of concern present.

2.2.2.2 Comparability

Comparability is the qualitative term that expresses the measure of confidence that two data sets or batches can contribute to a common analysis and evaluation. Comparability, with respect to laboratory analyses, pertains to method type comparison, holding times, stability issues, and aspects of overall analytical quantitation. The following items are determined when assessing data comparability:

- If two data sets or batches contain the same set of parameters;
- If the units used for each data set are convertible to a common metric scale;
- If similar processing procedures, analytical methods, and QA were used to collect data for both data sets;
- If the analytical instruments used for both data sets have approximately similar reporting limits; and
- If samples within data sets were selected and collected in a similar manner.

To ensure comparability of data collected during this investigation to other data that may have been or may be collected for each property, standard collection and measurement techniques will be used.

2.2.2.3 Completeness

Completeness is calculated for the aggregation of data for each analyte measured for any particular sampling event or other defined set of samples. Completeness is calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. For completeness requirements, valid results are all results not rejected through data validation. The requirement for completeness is 95% for aqueous samples and 90% for soil and sediment samples.

The following formula is used to calculate completeness:

$$\%\ \text{completeness} = \frac{\text{number of valid results} \times 100}{\text{number of possible results}}$$

For any instances of samples that could not be analyzed for any reason (e.g., holding time violations in which re-sampling and analysis were not possible, and samples spilled or broken), the numerator of this calculation becomes the number of valid results minus the number of possible results not reported. For this investigation, all samples are considered critical. Therefore, standard collection (as defined in the sampling SOPs in Appendix D) and measurement methods will be used to achieve the completeness goal.

2.2.2.4 Precision

Precision measures the reproducibility of measurements. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions.

Analytical precision is the measurement of the variability associated with duplicate (two) or replicate (more than two) analyses. The relative percent difference (RPD) between a field or “native” sample and the corresponding laboratory duplicate sample determines the precision of the analytical method. If the RPD of the analytes in the laboratory duplicate analysis are within established control limits, then precision is within limits.

Total precision is the measurement of the variability associated with the entire sampling and analysis process. Total precision is determined by analysis of duplicate, replicate and/or spiked samples and measures variability introduced by both the laboratory and field operations. Matrix duplicate spiked samples shall be analyzed to assess field and analytical precision, and the precision measurement is determined using the RPD between the duplicate sample results.

The following formula is used to calculate precision:

$$RPD = (100) \times \frac{(S1 - S2)}{(S1 + S2)/2}$$

where:

S1 = original sample value
S2 = duplicate sample value

In general, precision less than or equal to 35% RPD will fulfill the DQOs.

2.2.2.5 Accuracy

Accuracy is a statistical measurement of correctness and includes components of random error (variability due to imprecision) and systemic error. It reflects the total error associated with a measurement. Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction. Blanks, matrix spikes, laboratory control samples, and other reference materials are used to determine bias. A measurement is accurate when the value reported does not differ from the true value or known concentration of the spike and standard. Analytical accuracy is measured by comparing the percent recovery of analytes spiked into a laboratory control sample, surrogate, or matrix spike sample to a control limit. For PCBs, VOCs, and SVOCs, system monitoring compound recoveries are also used to assess accuracy and method performance for each sample analyzed. Analysis of performance evaluation samples may also be used to provide additional information for assessing the accuracy of the analytical data produced. In general, accuracy between 60% and 140% will fulfill the DQOs. Spike sample results below the QC limits may indicate a low bias, while spike sample results above the QC limits may indicate a high bias.

2.2.2.6 Sensitivity

Sensitivity is the determination of the minimum concentration or attribute that can be measured by a Method Detection Limit and Method Reporting or Quantitation Limit. Methods selected for this project are expected to provide sufficient sensitivity to yield reporting or quantitation limits that are below the lowest reference value for this study.

2.3 Special Training Requirements/Certification

No special training requirements or certifications are required for this project except for the 40-hour Hazardous Waste Operations and Emergency Response class and annual refreshers. Health and safety procedures for E & E personnel are addressed in E & E's site-specific Health and Safety Plan. This document will be present on site during the field event and will be stored in E & E's Seattle office after the field event. The plan includes descriptions of anticipated chemical and physical hazards, required levels of protection, health and safety monitoring requirements and action levels, personal decontamination procedures, and emergency procedures.

2.4 Documentation and Records

This document is meant to be combined with information presented in E & E's *Region 10 START-IV Quality Assurance Project Plan* (E & E 2013b). This information is covered by the SOPs provided in Appendix D, and the supplemental forms are provided in Appendix E. A copy of the START-IV QAPP is available at E & E's Seattle office. Standards contained in the SOPs, the START-IV QAPP, and the QMP will be used to ensure the validity of data generated by E & E for this project.

Following the completion of field work and the receipt of analytical data, E & E will prepare a report summarizing project findings. E & E will provide project files, including work plans, reports, analytical data packages, correspondence, COC documentation, logbooks, corrective action forms, referenced materials, geographic information system (GIS) deliverables/supporting data, the Scribe final .bac file, and photographs to the EPA TM at the close of the project. A CD-ROM deliverable containing the final report will be provided as well.

E & E will assemble and fully document a digital data set that includes all project sampling, analysis, and observation data. These digital data will be made available in a Microsoft Excel format.

E & E will transfer this data set and documentation to the EPA or, if requested, to any other EPA contractor and will ensure that any data transferred are received in an uncorrupted, comprehensible, and usable format. Specific data deliverable elements are presented below.

Field Information

The field information table contains all sample collection related information. To the extent possible, sample information (e.g., sample numbers, containers, analytical methods, sample jars, laboratories, etc.) is entered into Scribe (EPA's data handling software program) prior to the field event. Remaining field information including date sampled, time sampled, QA sample identification, depth sampled, airbill tracking numbers, method of delivery, and water quality readings is entered into Scribe after each sampling day as part of sample documentation in accordance with requirements specified in the EPA Region 10 DMP (EPA 2014a). The field information table structure from the Sample Information System is presented below.

Field Name	Type	Size	Description
Sample-Num	Character	10	Sample Number
Station	Character	10	Station Identifier
Date	Date	8	Sample Date
Time	Numeric	4	Sample Time (24-hour clock)
Sampler	Character	25	Person Name
Matrix	Character	6	Sample Matrix (i.e., soil boring, groundwater, sediment)
Water Depth	Numeric	5.1	Depth of Water at Sediment Sample
Description	Character	40	Sample Description
Comments	Character	40	Comments

Location

The location table contains sample location coordinate information. The sample locations will be determined using Trimble GeoXH units. E & E personnel have been trained on these units and have utilized them for similar projects. For each day or half-day in the field that GPS sample location data are to be collected, the GPS user will create a single file that contains the locations of each sample station. All GPS locational data will be entered into Scribe, including elevation and land survey data if gathered. The GPS data entered into Scribe will be in decimal degrees, to six decimal places, using World Geodetic System 1984 (WGS84) datum. The revised Scribe file also will be provided to the EPA RSCC and/or SMO portal as a resubmission.

A unique station label will be entered for each sample location. This unique station identifier will be used to link the "Location" table with the "Field-Info" table. All locational data for this project will be stored in decimal degrees and will be referenced to the WGS84 horizontal datum. Differential corrections will be made real-time. The table structure is presented below.

Field Name	Type	Size	Description
Station	Character	10	Station Identifier

X-Coord	Numeric	12.6	X-Coordinate, Decimal Degrees
Y-Coord	Numeric	12.6	Y-Coordinate, Decimal Degrees

E & E will provide any GIS-produced maps to the EPA in both hard copy and digital image (i.e., .jpeg) formats.

Lab Analytical

Field screening analytical data will be entered into Scribe either daily or at the close of the field project. The Lab Analytical table for fixed laboratory data will hold all of the sample analysis results provided by each laboratory analyzing samples. The integrity of each data file received from the laboratories will be checked and verified. An E & E validation chemist or the PM will perform a 10% or more check of only the positive results by comparing the hard copy data against the electronic data deliverable (EDD) for sample numbers, locations, concentrations, and qualifiers. The data file verification performed by the validation chemist and PM will likely have some overlap. Once the files are received, they will be appended into the Site Data Management System Lab Analytical table. The “Sample-num” field will be used to link the “Lab Analytical” table with the “Field-Info” table. Prior to project closeout, fixed laboratory data will be imported into Scribe. Final validated laboratory results will be imported into Scribe prior to the production of the final report and published to Scribe.net. The E & E sample information system table structure is presented below.

Field Name	Type	Size	Description
Sample-num	Character	10	Sample Number
Lab-id	Character	10	Laboratory Sample Identifier
Method	Character	25	Analytical Method Used
L-Matrix	Character	10	Laboratory Matrix
Cas-num	Character	15	Chemical Abstracts
Analyte	Character	40	Analyte Name
Result	Numeric	12.6	Analysis Result
Qual	Character	6	Sample Qualifier
Quantitation-Limit	Numeric	12.6	Sample Quantitation Limit
Units	Character	10	Results Unit
Date	Date	8	Date Analyzed
Lab	Character	40	Lab Name

3 Measurement/Data Acquisition

3.1 Cooler Return

For laboratories other than the EPA MEL, E & E will provide completed air bills accompanied by plastic envelopes with adhesive backs and address labels in the COC bags taped to the inside of the cooler lids so the laboratory can return the coolers to E & E. The air bills will contain the following notation:

> *Transportation is for the United States Environmental Protection Agency, and the total actual transportation charges paid to the carrier(s) by the consignor or consignee shall be reimbursed by the Government, pursuant to cost reimbursement contract number EP-S7-13-07.*

This notation will enable the laboratories to return the sample coolers to E & E's warehouse. The air bills will be marked for second-day economy service and will contain the appropriate Task Order, Subtask number for shipment.

E & E has made other arrangements with the EPA MEL and commercial laboratories so this manner of cooler return is not required when working with them.

3.2 Sample Handling and Custody Requirements

This subsection describes sample identification and COC procedures that will be used for the Gunshy Manor field activities. The purpose of these procedures is to ensure that the quality of the samples is maintained during collection, transportation, storage, and analysis. All COC requirements comply with E & E's SOPs for sample handling and EPA Region 10 sample management/Scribe requirements. All sample control and COC procedures will follow the EPA's (2014a) *Contract Laboratory Program Guidance for Field Samplers*.

Examples of sample documents used for custody purposes are provided in Appendix E (with the exception of field logbooks) and include the following:

- Sample identification numbers;
- Sample labels;
- Custody seals;

- COC records or traffic reports;
- Field logbooks;
- Sample collection forms;
- Analytical request forms; and
- Analytical records.

During the field effort, the PM or delegate is responsible for maintaining an inventory of the sample documents. This inventory will be recorded in a cross-referenced matrix of the following:

- Sample location;
- Sample identification number;
- Analyses requested and request form numbers;
- COC record numbers;
- Bottle lot numbers; and
- Air bill numbers.

Brief descriptions of the major sample identification and documentation records and forms are provided below.

3.3 Sample Identification

All samples will be identified using the sample numbers assigned by the EPA RSCC. Each sample label will be affixed to the jar and covered with clear tape. A handwritten sample tracking record will be kept as each sample is collected. While in the field, samples will be tracked in the field logbook. At the end of each day, sample information will be entered into Scribe. The following will be recorded into Scribe: location information, matrix type, sample number, observations, sample depth, any field measurements/monitoring data, sample collection date/time, GPS coordinates, and final lab results. In addition to the EPA-assigned sample number, samples will be tracked with a sample code system designed to allow easy reference to the sample's origin and type. The sample code key will not be provided to the laboratory. Table 3-1 summarizes sample coding for this project. The sample locational data must be imported into Scribe and a regenerated COC .xml and .xls file must be provided to EPA RSCC/SMO Portal/Scribe.net within 14 days of the last shipment.

3.3.1 Sample Labels

To minimize the handling of sample containers, labels will be completed before sample collection, to the greatest extent possible. In the field, the label will be filled out completely using waterproof ink, and then attached firmly to the sample containers and protected with clear tape. The sample label will provide the following information:

- Sample number, CLP and Region 10;

- Container ID code (“tag” number);
- Sample location number;
- Date and time of collection;
- Analysis required;
- CLP case number and EPA project code; and
- Preservation (when applicable).

Field sample identification will be sufficient to enable cross-reference with the project logbook. For COC purposes, all QA/QC samples will be subject to the same custodial procedures and documentation as site samples.

3.3.2 Custody Seals

Custody seals are preprinted gel-type seals that are designed to break into small pieces if disturbed. Sample shipping containers (e.g., coolers, drums, cardboard boxes, as appropriate) will be sealed in as many places as necessary to ensure security. Seals will be signed and dated before use. Clear tape may be placed perpendicularly over the seals on the cooler seam to ensure that they are not broken accidentally during shipment. An internal custody seal also will be signed and placed over the taped-closed cooler interior “drum liner” bag that encloses all cooler contents. Upon receipt at the laboratory, the custodian will check (and certify by completing the package receipt log) that seals on shipping containers are intact.

3.3.3 Chain-of-Custody Records and Traffic Reports

For samples to be analyzed at the EPA MEL or at a CLP laboratory, the COC records, analyses required forms, and/or analytical traffic report forms will be completed as described in the *Contract Laboratory Program Guidance for Field Samplers* (EPA 2014b) and according to the EPA Region 10 DMP Scribe requirements (EPA 2014a). The EPA’s Scribe software developed by the EPA’s Environmental Response Team will be used to electronically enter information. Scribe will be used to manage all data generated for the project by capturing location information, matrix type, sample numbers, field observations, sample depth, any field measurements/ monitoring data, sample collection date/time, GPS coordinates, and final laboratory results. Scribe will also be used to generate COC records and traffic report forms.

The laboratory COC records, required analyses forms, and analytical traffic reports will be completed fully by the field technician designated by the PM as responsible for sample shipment to the appropriate laboratory. Copies of these documents will be in .xml format and uploaded to the CLP SMO portal on each day of shipment. The project file is also published to Scribe.net daily. The COC .xml and Region 10 Custom Data View .xls will also be sent to the RSCC on each day of shipment. Information specified on the COC record will contain the same level of detail found in the site logbook, except that the on-site measurement data will not be recorded. The custody record will include the following information:

- Name and company or organization of person collecting the samples;
- Date of sample collection;
- Type of sampling conducted (composite or grab);
- Sample number (using those assigned by the EPA RSCC);
- CLP case number and/or EPA project code;
- Location of sampling station (using the sample code system provided in Table 3-1);
- Number and type of containers shipped;
- Analysis requested; and
- Signature of the person relinquishing samples to the transporter, with the date and time of transfer noted and signature of the designated sample custodian at the receiving facility.

If samples require rapid laboratory turnaround, the person completing the COC record(s) will note these or similar constraints in the remarks section of the COC record.

The relinquishing individual will record all shipping data (e.g., air bill number, organization, time, and date) in Scribe for COC generation and this COC record will be transported with the samples to the laboratory and retained in the laboratory's file. Original and duplicate COC records, together with the air bill(s) or delivery note(s), constitute a complete custody record. It is the PM's responsibility to ensure that all records are consistent and that they become part of the permanent job file.

3.3.4 Field Logbooks and Data Forms

Field logbooks (or daily logs) and data forms are necessary to document daily activities and observations. All data and observations are hand documented in a field logbook. Documentation will be sufficient to enable participants to reconstruct events that occurred during the project accurately and objectively at a later time. All daily logs will be kept in a bound notebook containing numbered pages. All entries will be made in waterproof ink, dated, and signed. No pages will be removed for any reason.

Minimum logbook content requirements are described in the E & E SOP entitled *Field Activity Logbooks*, provided in Appendix D. Any necessary corrections will be made by drawing a single line through the original entry (so that the original entry is legible) and writing the corrected entry alongside. The correction will be initialed and dated. Corrected errors may require a footnote explaining the correction.

3.3.5 Photographs

Photographs will be taken as directed by the PM or site manager. Documentation of a photograph is crucial to its validity as a representation of an existing situation. The following information will be noted in the project or task log concerning photographs:

- Date, time, and location where photograph was taken;
- Photographer (initials);
- Weather conditions;
- Description of photograph taken;
- Reasons why photograph was taken;
- Sequential number of the photograph;
- Camera lens system used; and
- Direction photograph was taken.

3.4 Custody Procedures

The primary objective of COC procedures is to provide an accurate written or computerized record that can be used to trace the possession and handling of a sample from collection to completion of all required analyses. A sample is in custody when it is:

- In someone's physical possession,
- In someone's view,
- Locked up, or
- Kept in a secured area that is restricted to authorized personnel.

3.4.1 Field Custody Procedures

The following guidance will be used to ensure proper control of samples while in the field:

- As few people as possible will handle samples.
- Coolers or boxes containing cleaned bottles will be sealed with a custody tape seal during transport to the field or while in storage before use. Sample bottles from unsealed coolers or boxes or bottles that appear to have been tampered with will not be used.
- The sample collector will be responsible for the care and custody of collected samples until they are transferred to another person or dispatched properly under COC rules.
- The sample collector will record sample data in the field logbook.
- The PM will determine whether proper custody procedures were followed during the field work and whether additional samples are required.

When transferring custody (i.e., releasing samples to a shipping agent), the following will apply:

- The coolers in which the samples are packed will be sealed and accompanied by the original COC record. When transferring samples, the individuals relinquishing and receiving them must sign, date, and note the time on the COC record. This record will document sample custody transfer.
- Samples will be dispatched to the laboratory for analysis with separate COC records accompanying each cooler. The COC records will be signed by the relinquishing individual, and the method of shipment, name of courier, and other pertinent information will be entered on the COC record before placement in the shipping container. Shipping containers will be sealed with custody seals for shipment to the laboratory.
- Each cooler shipped will be accompanied by COC records identifying its contents. The original COC records will be placed in a zip-locking bag and placed inside the cooler. Copies of the COC records will be maintained by the PM.
- If sent by common carrier, a bill of lading will be used. Freight bills and bills of lading will be retained as part of the permanent documentation file. Each cooler and associated COC record will have a separate tracking number assigned.

3.4.2 Laboratory Custody Procedures

A designated sample custodian at the laboratory will accept custody of the shipped samples from the carrier and enter preliminary information about the package into a package or sample receipt log, including the initials of the person delivering the package and the status of the custody seals on the coolers (i.e., broken versus unbroken). The custodian responsible for sample log-in will follow the laboratory's SOP for opening the package, checking the contents, and verifying that the information on the COC record agrees with the samples received. The laboratory will check the temperature blank inside the cooler and document it in the sample log-in form. Should the temperature be greater than what is required by the SOW or the method, the sample custodian will inform the region and follow the course of actions stipulated in the SOW or specified by the regional QAO.

3.5 Analytical Methods Requirements

This section describes the analytical strategy (Section 3.5.1) and the analytical methods (Section 3.5.2) that will be used for this project.

3.5.1 Analytical Strategy

Analysis of samples collected during the sampling event will be performed by several possible means. The MEL (or an alternative CLP laboratory designated by the EPA) will perform all requested analysis.

The analyses to be applied to samples sent to the laboratory are listed in Table 1-3. These analyses were selected based on the probable hazardous substances used or potentially released to the environment, given the known or suspected site usage.

3.5.2 Analytical Methods

Samples designated for off-site analytical laboratory analyses will be submitted to the EPA Region 10 MEL, or an alternative laboratory designated by the EPA. MEL laboratory analysis and MEL QA chemist data validation for samples submitted to MEL will take place in an eight-week turnaround time period. CLP laboratory analyses will take place within the standard three-week turnaround time period. EPA QA chemist's validation of CLP laboratory data will take place within the standard three-week turnaround time. Electronic data results from the MEL and/or CLP laboratories will be delivered to the EPA and E & E upon completion of each sample delivery group. EDD results from the MEL and/or CLP laboratories will be delivered to the EPA upon project completion. All MEL and CLP data will be reported electronically in the Region 10 Universal Superset EDD format as defined in the EPA Region 10 DMP (EPA 2014a). Table 1-3 summarizes laboratory instrumentation and methods to be used for the Gunshy Manor sampling.

All instruments and equipment used during field and fixed laboratory sample analyses will be operated, calibrated, and maintained according to the manufacturer's guidelines and recommendations, as well as criteria set forth in the applicable analytical methodology references.

In cases where laboratory results exceed QC acceptance criteria, reextraction and/or reanalysis will occur as indicated in the applicable analytical method.

3.6 Quality Control Requirements

QC checks for sample collection will be accomplished by a combination of COC protocols and laboratory QA procedures as prescribed in the sampling or analytical methods. No QC samples (i.e., double blind performance evaluation samples) are planned for this activity outside of the normal laboratory QC criteria outlined in the analytical methods. These QC samples include blanks (field and/or laboratory method), calibration verifications, spikes (matrix and blank), duplicates, interference check samples (for inorganics), and serial dilutions. Results from these samples will be compared to the QC requirements listed in Section 5.1.2. All analyses that will be performed for this project will produce definitive data. DQI targets for this project are specified in Subsection 2.2 and are summarized in Table 1-3 of this SQAP. Bias for estimated qualified data will be determined by the validation process. In accordance with the objectives outlined in this document and the QA levels defined by the EPA (EPA 1993), the EPA has defined the DQOs and has determined that the sampling and analyses performed under this sampling effort will conform to the definitive data without quantitative error and bias determination criteria. The laboratories' DQOs for completeness and the field team's ability to meet the DQO for representativeness are set at 90%. Precision and accuracy requirements are outlined in Table 1-3.

One temperature blank consisting of a plastic vial of tap water will be included in each cooler shipped to the CLP analytical laboratories. Temperature blanks allow the laboratories to obtain a representative measurement of the temperature of samples enclosed in a cooler without disturbing the actual samples. The analytical laboratory will only measure the temperature of the blank. The temperature blank will not be analyzed for hazardous substances, will not be given a sample number, and will not be listed on the COC form. The temperature blank will be clearly labeled: TEMP BLANK. Temperature blanks are not required for shipments to EPA Region 10 MEL since MEL staff measure the temperature of every cooler using a probe and/or calibrated infra-red gun for each sample.

3.7 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

The field equipment to be used during this project includes the GPS unit, flame ionization detector, and the Geoprobe™. Testing, inspection, and maintenance of these instruments will be performed in accordance with the manufacturers' recommendations and/or the SOPs listed in Subsection 1.5.3. Spare parts for the field equipment will be available from the manufacturer generally within 24 hours.

All field instruments and equipment used for analysis will be serviced and maintained only by qualified personnel. All instruments will be maintained by senior staff and/or electronics technicians. All repairs, adjustments, and calibrations will be documented in an appropriate logbook or on a data sheet that will be kept on file. The instrument maintenance logbooks will clearly document the date, description of the problems, corrective action taken, result of the action, and who performed the work.

All equipment used by E & E in the field is subject to standard preventive maintenance schedules established by corporate equipment protocols. When in use, equipment will be inspected at least twice daily: once before startup in the morning and again at the end of the work shift before overnight storage or return to the charging rack. Regular maintenance, such as cleaning lenses, replacing in-line filters, and removing accumulated dust, is to be conducted according to manufacturers' recommendations and in the field as needed, whichever is appropriate. All performed preventive maintenance will be entered in the individual equipment's logbook and in the site field logbook.

In addition to preventive maintenance procedures, daily calibration checks will be performed at least once daily before use and recorded in the respective logbooks. Additional calibration checks will be performed as required. All logbooks will become part of either the permanent site file or the permanent equipment file.

3.8 Instrument Calibration and Frequency

All instruments and equipment used during fixed laboratory sample analyses will be operated, calibrated, and maintained according to the manufacturers' guidelines and recommendations, as well as criteria set forth in the applicable analytical methodology references and/or in accordance with the laboratory's QA manual and SOPs.

For the field instrumentation (GPS unit and other instrumentation discussed previously), calibrations will be performed in accordance with the manufacturers' recommendations and the SOPs listed in Subsection 1.5.3.

3.9 Inspection/Acceptance Requirements for Supplies and Consumables

This information is covered by the SOPs, the START-IV QAPP (E & E 2013b), and the START-IV QMP (E & E 2013a). Standards contained in these documents will be used to ensure the validity of data generated by E & E for this project. Sample jars are pre-cleaned by the manufacturer, and certification documenting this is enclosed with each box of jars. The START-IV will include this documentation as part of the site file. Nondedicated equipment is demonstrated to be uncontaminated by the use of rinsate blanks.

3.10 Data Acquisition Requirements (Nondirect Measures)

During this environmental data acquisition activity, data may be obtained from nondirect measurement sources such as computer printouts and literature sources. The source of these data will be recorded, and the quality of the data will be assessed to determine if the data are consistent with project objectives and appropriate for supporting a specific decision. Usability or limitations of data, such as representativeness, bias, and precision, will be discussed with the TM, and any uncertainty will be assessed prior to the inclusion of data in the decision making process.

3.11 Data Management

This document is meant to be combined with information presented in E & E's QAPP and QMP for Region 10 START-IV. Copies of the START-IV QAPP and QMP are available in E & E's Seattle office. Standards contained in these documents will be used to ensure the validity of data generated by E & E for this project. Data validation will be performed as listed in Section 5.1.2. Electronic data will be archived by the site's project number and in accordance with a DMP (see Appendix F), that outlines where the various data streams generated as a component of this sampling event (e.g., photographs, field screening data, analytical data, and locational data) will be stored and/or transferred to the EPA. Additionally, all locational, field collection/sampling, shipment, custody, monitoring, and laboratory/field analytical data will be included in the project's Scribe file and will be sent to the RSCC, and published to Scribe.net within two weeks of the receipt and processing of validated electronic data. E & E will provide a CD containing the Scribe .bac file, monitoring data, analytical data, and

GIS products, as well as supporting data as documented in the EPA Region 10 DMP to the EPA TM when the project is completed.

4 Assessment/Oversight

4.1 Assessment and Response Actions

The EPA QAO or designee may conduct an audit of the field activities for this project. The auditor will have the authority to issue a stop work order upon finding a significant condition that adversely would affect the quality and usability of the data. The EPA TM will be responsible for initiating and implementing response actions associated with findings identified during the site audit. The actions taken also may involve the EPA Project Officer, contracting officer, and/or QAO. Once the response actions have been implemented, the EPA QAO or designee may perform a follow-up audit to verify and document that the response actions were implemented effectively. In-house audits performed by the START-IV may be conducted in accordance with the E & E START-IV *Quality Management Plan* (E & E 2013a). No audits are planned for the Gunshy Manor sampling event.

If major deviations from the QA requirements of the project and the CLP SOW are observed in the data validation process, the EPA QAO will contact the CLP SMO and the laboratory to correct the problem. If the laboratory is not responsive to the request, the QA chemist will inform the CLP Regional Contracting Officer's Representative and the TM of the situation. A brief narrative will be written explaining the contract deviations, and recommendations will be given based on the quality of the submitted data. Reduced payment and/or reanalysis at the laboratory's expense may be pursued by the Regional CLP Contracting Officer's Representative. Re-sampling and subsequent re-analysis will be decided by the TM. Additional sampling for corrective actions and/or any addendum to this SQAP shall be documented using the Corrective Action Form and the Sample Plan Alteration Form (see Appendix C). Corrective actions will be conducted in accordance with E & E QMP specifications.

4.2 Reports to Management

The START-IV PM will debrief the EPA TM on a daily basis. Laboratory deliverables will be as specified in the CLP Organic and Inorganic SOWs (SOM02.4 and ISM02.4, respectively) for CLP data, CLP-equivalent deliverables for MEL data. Once the project is complete and the resulting data obtained, the START-IV PM will prepare a final project report. The report will include a summary of the activities performed during the project and the resulting data (along with any statements concerning data quality). The report will be approved by the EPA TM prior to being forwarded to the individuals identified in the data distribution list located in the Table of Contents section of this SQAP.

The START-IV corrective action program is addressed in Section 3 of the QMP. Corrective actions will be conducted in accordance with these QMP specifications.

5 Data Validation and Usability

5.1 Data Review, Validation, and Verification Requirements

The data validation review of data packages will include an evaluation of the information provided on the analytical data sheets and required support documentation for all sample analyses; the supporting sample collection documentation, including COC forms and documentation of field instrument calibration, sample results, and/or performance checks (if required by the method). The QA review also will examine adherence to the procedures as described in the cited SOPs and the analytical methods specified in the SQAP.

5.1.1 Data Reduction

Data reduction includes all processes that change the numerical value of the raw data. All fixed-laboratory data reduction will be performed in accordance with the appropriate methodology and will be presented as sample results.

5.1.2 Data Validation

Analytical data generated through the CLP contract will be validated in a three-week turnaround time by an EPA Region 10 QA chemist. Data generated by the MEL will be reviewed and qualifiers will be applied by staff at the MEL, equivalent to a Stage 4 Validation Manual (S4VM) validation (EPA 2009) in a four-week turnaround time period (8 weeks total from receipt of last sample). CLP data are reported with electronic validation automatically via EXES – inorganic and organic are validated electronically using Stage 3 Validation Electronic. The EPA QA group then performs additional Stage 4 Validation Electronic and Manual (S4VEM) validation on all CLP data (EPA 2009). All data validations will be performed in accordance with the QA/QC requirements specified in the SQAP, the technical specifications of the analytical methods, laboratory SOPs (for non-CLP methods), and the following documents:

- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (EPA 2017a); and
- *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (EPA 2017b).

The QC parameters of interest for the EPA organic and inorganic methods that will be used on samples are presented in these documents. When applicable, QC criteria listed in the applicable analytical methods and/or the SOW will be used for validation. Sample qualifications based on field blank results (when collected) will be applied in the same manner as qualifications based on laboratory method blank results.

Validation deliverables will include a QA memo discussing QA conformance and deviation issues that may have affected the quality of the data. Data usability, bases of application of qualifiers, and percentage of qualified data will also be discussed in the sampling report. The analysis data sheets (Form I or equivalent) with the applied validation qualifiers will also be a part of the validation deliverables. MEL staff performs verification of data generated at the EPA laboratory equivalent to S4VM validation. Data qualifiers will be determined by the EPA QA staff for CLP-generated data during S4VEM validation. Where more than one result was reported for a single sample and compound by the CLP lab, EPA QA will identify the appropriate result for use and R-qualify (reject) in the final validation qualifier column all other reported results (e.g., dilution and re-extraction) for that single sample/compound. The following qualifiers shall be used in data validation:

- U = The material was analyzed for but was not detected. The associated numerical value is the sample quantitation limit.
- J = The associated numerical value is an estimated quantity because the reported concentrations were less than the sample quantitation limits or because QC criteria limits were not met.
- UJ = The material was analyzed for but was not detected. The reported detection limit is estimated because QC criteria were not met.
- R = The sample results are rejected (analyte may or may not be present) due to gross deficiencies in QC criteria. Any reported value is unusable. Resampling and/or reanalysis is necessary for verification.
- H = The sample result is biased high.
- K = The bias of the sample is not known.
- L = The sample result is biased low.
- Q = Detected concentration is below the method reporting limit/Contract Required Quantitation Limit, but is above the method quantitation limit.

If more than one result is reported by the laboratory for a sample/analyte/compound due to dilutions, re-extractions, re-analyses, select ion monitoring results, etc., the reviewer will clearly identify which individual result should be used and reject (R-qualify) all other results.

5.1.3 Data Assessment Procedures

Following data validation and reporting, all project-generated and compiled data and information will be reconciled with the objectives specified in Section 1 to assess the overall success of sampling activities. This data assessment, including points of achievement and departure from project-specific objectives, will be discussed in the QA section of the sampling trip report.

5.2 Data Verification

The analytical QA requirements and data validation requirements will be as specified in Section 5.1.2 (EPA 2017a, 2017b, 2016).

The EPA TM will perform the final review and approval of the data. The EPA TM and/or QA staff will look at matrix spike/matrix spike duplicates, laboratory blanks, and laboratory duplicates to ensure that they are acceptable. The EPA TM and/or designee also will compare the sample descriptions with the field sheets for consistency and will ensure that any anomalies in the data are documented appropriately.

Data QA memoranda reports will be generated as part of the Gunshy Manor sampling if the START-IV is responsible for data validation. If the EPA Region 10 QA office or its designee performs the data validation, then additional reports regarding data usability will be generated by the START-IV PM.

5.3 Reconciliation with Data Quality Objectives

The DQI targets for this project are discussed in Section 2.2.2 and Table 1-4 of this SQAP. The data validation will be used as a tool to determine if these targets were met. In addition, using the compiled data, E & E and the TM will determine the variability and soundness of the data and the data gaps that will need to be filled to meet the objectives of the project.

Once the data results are compiled, the EPA TM and/or the EPA QAO will review the sample results to determine if they fall within the acceptance limits as defined in this SQAP. Completeness also will be evaluated to determine if the completeness goal for this project has been met. If DQIs do not meet the project's requirements as outlined in this SQAP, the data may be discarded and resampling and reanalysis may be done. The TM will attempt to determine the cause of the failure (if possible) and make the decision to discard the data and resample. If the failure is tied to the analysis, calibration and maintenance techniques will be reassessed, as identified by the appropriate laboratory personnel. If the failure is associated with the sample collection and resampling is required, the collection techniques will be reevaluated as identified by the START-IV PM.

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Tables

Table 1-1 Groundwater Drinking Water Populations by Distance Ring

Distance Ring (miles)	Number of Wells	Population Served	Total Population Served
0 – ¼	1 Domestic Wells	2	2
¼ – ½	3 Domestic Wells	7	7
½ – 1	18 Domestic Wells	44	52
	2 Group B Community Wells	8	
1 – 2	104 Domestic Wells	255	55,288
	4 City of Redmond Group A Wells	54,940	
	13 Group B Community Wells	93	
2 – 3	132 Domestic Wells	323	22,772
	1 City of Redmond Group A Well	13,735	
	3 Union Hill Water Association Group A Wells	4,958	
	3 Northeast Sammamish Sewer and Water District Group A Wells	3,498	
	29 Group B Community Wells	258	
3 – 4	225 Domestic Wells	551	1,181
	2 Dawn Breaker Water Association Group A Wells	168	
	35 Group B Community Wells	462	
Total			**79,302**

Note: The average number of persons per household for King County, Washington is 2.45. The population served for each domestic well calculated by multiplying the number of wells by 2.45.

Population values were rounded to the nearest whole number.

Table 1-2 Sample Information Summary

Project Sampling Schedule	Design Rationale	Sampling Design Assumptions	Measurements Classification (Critical/Noncritical)	Nonstandard Method Validation
Soil (subsurface)	Determine if contaminants are present.	Contaminants are present in site sources	Critical	NA
Groundwater	Determine if contaminants are present or are migrating from site sources	Contaminants are present in site sources and may be migrating from site sources	Critical	NA

Key:
NA = Not applicable.

Table 1-3 Sample Analysis Summary and QA/QC Analytical Summary and Fixed Laboratory Analytical Methods

Matrix/ Location [a]	Proposed Laboratory	Analytical Parameters/Methods/Description and Detection Limits	Precision and Accuracy [b]	Technical Holding Times [c]	Sample Preservation	Sample Containers / MS/MSD or Laboratory Duplicate Sample Container	Number of Field Samples	Number of MS/MSD and Laboratory Duplicate Samples[d]	Total Number of Sample Containers
Soil	CLP or MEL	SVOCs + PAH SIM/ EPA CLP SOW SOM02.4 (or current SOW) or EPA SW-846 8270D/ GC-MS/CRQL – Low + SIM	± 35% 50% - 150%	14 days to extraction 40 days to analysis	≤6°C	1x8-ounce glass/ 1x8-ounce glass	18	1 (PCBs only)	19
		PCB Aroclors/ EPA CLP SOW SOM02.4 (or current SOW) or EPA SW-846 8082A/GC-ECD/CRQL	± 35% 50% - 150%	14 days to extraction 40 days to analysis (no holding time limits for 8082 PCBs)	≤6°C				
		TAL Metals (Mercury listed on the next row)/ EPA CLP SOW ISM02.4 (or current SOW) or EPA SW-846 3050B+6010D+ 6020B/ ICP-AES+MS/CRQL (MS needed for arsenic and cadmium, all other elements AES)	± 35% 75% - 125%	180 days	≤6°C	1x8-ounce glass/ NA	18	1	18
		Mercury/ EPA CLP SOW ISM02.4 (or current SOW) or EPA SW-846 7471B/CVAAS/CRQL	± 35% 75% - 125%	28 days	≤6°C				
		VOCs/ EPA CLP SOW SOM02.4 (or current SOW) or EPA SW-846 8260D/GC-MS/CRQL - Low	± 35% 50% - 150%	48 hours	≤6°C	3xCore-N-One & 1x2 ounce glass/NA	18	NA	54 Core-N-One + 18 2-ounce jars
	MEL	Gasoline Range TPHs/NWTPH-Gx /GC-FID/ 10 mg/kg	± 35% 50% - 150%	48 hours	≤6°C	3xCore-N-One glass/ 6xCore-N-One	18	2	54
		Diesel-Range, Residual- and Motor Oil-Range TPHs/NWTPH-Dx /GC-FID/ 40 mg/kg and 100 mg/kg	± 35% 50% - 150%	14 days to extraction 40 days to analysis	≤6°C	1x8-ounce glass/ NA	18	2	18
Water	CLP or MEL	SVOCs + PAH SIM/ EPA CLP SOW SOM02.4 (or current SOW) or EPA SW-846 8270D/ GC-MS/CRQL – Low + SIM	± 20% 60% - 140%	7 days to extraction 40 days to analysis	≤6°C	2x32 ounce glass amber/NA	9	NA	18
		PCB Aroclors/ EPA CLP SOW SOM02.4 (or current SOW) or EPA SW-846 8082A/ GC-ECD/CRQL	± 20% 60% - 140%	7 days to extraction 40 days to analysis (no holding time limits for 8082 PCBs)	≤6°C	2x32 ounce glass amber/ 6x32 ounce glass amber	9	1	22
		TAL Metals / EPA CLP SOW ISM02.4 (or current SOW) or EPA SW-846 3050B+6010D+6020B/ ICP-AES+MS/CRQL (MS needed for arsenic and cadmium, all other elements AES)	± 20% 75% - 125%	180 days	pH ≤ 2 with HNO_3	1x1-liter polyethylene/ 2x1-liter polyethylene	9	1	10
		Mercury/ EPA CLP SOW ISM02.4 (or current SOW) or EPA 245.1/CVAAS/CRQL	± 20% 75% - 125%	28 days	pH ≤ 2 with HNO_3				

Matrix/ Location [a]	Proposed Laboratory	Analytical Parameters/Methods/Description and Detection Limits	Precision and Accuracy [b]	Technical Holding Times [c]	Sample Preservation	Sample Containers / MS/MSD or Laboratory Duplicate Sample Container	Number of Field Samples	Number of MS/MSD and Laboratory Duplicate Samples[d]	Total Number of Sample Containers
		VOCs/ EPA CLP SOW SOM02.4 (or current SOW) or EPA SW-846 8260D/GC-MS/CRQL – Trace	± 20% 60% - 140%	14 days	≤6°C, pH ≤ 2 with HCl	5x40-mL glass/NA	9	NA	45
	MEL	Gasoline Range TPHs/NWTPH-Gx/GC-FID/ 50 µg/L	± 20% 60% - 140%	14 days	≤6°C, pH ≤ 2 with HCl	3x40-mL glass/ 6x40-mL glass	9	1	30
		Diesel-Range, Residual- and Motor Oil-Range TPHs/NWTPH-Dx/GC-FID/ 2 µg/L and 500 µg/L	± 20% 60% - 140%	14 days to extraction 40 days to analysis	≤6°C, pH ≤ 2 with HCl	2x32 ounce glass amber/ 4x32 ounce glass amber	9	1	20
QA/QC Samples (Includes 2 rinsates, 1 IDW, and 2 trip blanks)	CLP or MEL	SVOCs + PAH SIM/ EPA CLP SOW SOM02.4 (or current SOW) or EPA SW-846 8270D/ GC-MS/CRQL – Low + SIM	± 20% 60% - 140%	7 days to extraction 40 days to analysis	≤6°C	2x32 ounce glass amber/NA[e]	3	NA	6
		PCBs/ EPA CLP SOW SOM02.4 (or current SOW) or EPA SW-846 8082A/ GC-ECD/CRQL	± 20% 60% - 140%	7 days to extraction 40 days to analysis (no holding time limits for 8082 PCBs)	≤6°C	2x32 ounce glass amber/ NA[e]	3	NA	6
		TAL Metals (Mercury listed on the next row)/ EPA CLP SOW ISM02.4 (or current SOW) or EPA SW-846 3050B+6010C+ 6020B/ ICP-ES+MS/CRQL (MS needed for arsenic and cadmium, all other elements AES)	± 20% 75% - 125%	180 days	pH ≤ 2 with HNO_3	1x1-liter polyethylene/NA[e]	3	NA	3
		Mercury/ EPA CLP SOW ISM02.4 (or current SOW) or EPA 245.1/CVAAS/CRQL	± 20% 75% - 125%	28 days	pH ≤ 2 with HNO_3				
		VOCs/ EPA CLP SOW SOM02.4 (or current SOW) or EPA SW-846 8260D/ GC-MS Trace/CRQL - Trace	± 20% 60% - 140%	14 days	≤6°C, pH ≤ 2 with HCl	5x40-mL glass/NA[e]	5	NA	25
	MEL	Gasoline Range TPHs/NWTPH-Gx / GC-FID/ 50 µg/L	± 20% 60% - 140%	14 days	≤6°C, pH ≤ 2 with HCl	3x40-mL glass/NA[e]	5	NA	15
		Diesel-Range, Residual- and Motor Oil-Range TPHs/NWTPH-Dx / GC-FID/ 2 µg/L and 500 µg/L	± 20% 60% - 140%	7 days to extraction 40 days to analysis	≤6°C, pH ≤ 2 with HCl	2x32 ounce glass amber/NA[e]	3	NA	6

Notes:
a = The number of samples presented is an estimate. The actual number of samples to be collected will be determined in the field.
b = Precision and accuracy are per method or SOW, as appropriate. In some cases, generic limits are listed in this table for comparison purposes.
c = Technical holding times have been established only for water matrices. Water technical holding times were applied to sediment, soil, and product samples where applicable; in some cases, recommended sediment/soil holding times are not listed.
d = MS/MSD samples are collected at a rate of 1 in 20. Laboratory duplicate samples for NWTPH methods are collected at a rate of 1 in 10.
e = No MS/MSD and laboratory duplicate samples are being collected for water QA/QC samples as these are field rinsate and/or trip blank samples collected only for QA/QC purposes. Likewise, MS/MSD samples are not being collected for VOCs and SVOCs as internal standards required from the analytical method/SOW monitor matrix specific QC performance in every sample.

Key:

° C =	Degrees Celsius	mg/kg =	milligrams per kilogram
µg/L =	micrograms per liter	mL =	Milliliter
AES =	Atomic Emission Spectrometer	MS =	Mass spectrometric detection
CLP =	Contract Laboratory Program	MS/MSD =	Matrix spike/matrix spike duplicate
CRQL =	Contract Required Quantitation Limit	NA =	Not applicable

CVAAS =	Cold Vapor Atomic Absorption Spectrophotometry
Dx =	Diesel Range
ECD =	Electron capture detection
EPA =	United States Environmental Protection Agency
FID =	Flame Ionization Detector
GC =	Gas Chromatograph
Gx =	Gasoline Range
HCl =	Hydrochloric acid
HNO_3 =	Nitric acid
ICP =	Inductively coupled argon plasma
MEL =	Manchester Environmental Laboratory
NWTPH =	Northwest Total Petroleum Hydrocarbons
PAH =	Polycyclic aromatic hydrocarbons
PCB =	Polychlorinated biphenyls
QA/QC =	Quality Assurance/Quality Control
SIM =	Selected ion monitoring
SOW =	Statement of Work
SVOCs =	Semivolatile Organic Compounds
TAL =	Target Analyte List
TPHs =	Total Petroleum Hydrocarbons
VOCs =	Volatile Organic Compounds

Table 1-4 Regulatory Criteria and Screening Levels

Analyte	CAS #	Soil: Quantitation Limits by Method (See Table 1-3 for further details on analytical methods)		Soil: MTCA A	Soil: MTCA B Non-cancer	Soil: MTCA B Cancer	Soil: MTCA B Protective of GW (Saturated)	Soil: EPA Residential Soil RSL	Groundwater: Quantitation Limits by Method (See Table 1-3 for further details on analytical methods)		Groundwater: MTCA A	Groundwater: MTCA B Non-cancer	Groundwater: MTCA B Cancer	Groundwater: EPA MCL	Groundwater: EPA Groundwater RSL
Metals		ICP-AES (mg/kg)	ICP-MS (mg/kg)	(mg/kg)					ICP-AES (µg/L)	ICP-MS (µg/L)	(µg/L)				
Antimony*	7440-36-0	6	1	--	32	--	0.27	31	60	2	--	6.4	--	6	7.8
Arsenic*	7440-38-2	1	0.5	20	24	0.67	0.15	0.68	10	1	5	4.8	0.058	10	0.052
Barium	7440-39-3	20	5	--	16,000	--	83	15000	200	10	--	3,200	--	2000	3800
Beryllium*	7440-41-7	0.5	0.5	--	160	--	3.2	160	5	1	--	32	--	4	25
Cadmium	7440-43-9	0.5	0.5	2	80	--	--	71	5	1	5	8	--	5	--
Chromium	7440-47-3	1	1	2,000 [a]	120,000 [a]	--	24,000 [a]	120000	10	2	50	24,000 [a]	--	100	--
Cobalt	7440-48-4	5	0.5	--	--	--	--	23	50	1	--	--	--	--	6
Copper	7440-50-8	2.5	1	--	3200	--	14	3100	25	2	--	640	--	1300	800
Lead	7439-92-1	1	0.5	250	--	--	150	400	10	1	15	--	--	15	15
Manganese	7439-96-5	1.5	0.5	--	11,000	--	--	1800	15	1	--	2200	--	--	430
Mercury	7439-97-6	0.1	0.1	2	--	--	0.1	11	0.2	0.2	2	--	--	2	0.63
Nickel	7440-02-0	4	0.5	--	1,600	--	6.5	1500	40	1	--	320	--	--	390
Selenium*	7782-49-2	3.5	2.5	--	400	--	0.26	390	35	5	--	80	--	50	100
Silver	7440-22-4	1	0.5	--	400	--	0.69	390	10	1	--	80	--	--	94
Thallium*	7440-28-0	2.5	0.5	--	0.8	--	0.011	0.78	25	1	--	0.16	--	2	0.2
Vanadium	7440-62-2	5	2.5	--	400	--	80	390	50	5	--	80	--	--	86
Zinc	7440-66-6	6	1	--	24,000	--	300	23000	60	2	--	4,800	--	--	6000
Polychlorinated Biphenyls		CLP Low (µg/kg)		(µg/kg)					CLP Low (µg/L)	--	(µg/L)				
Aroclor 1016	12674-11-2	33		--	5,600	14,000	--	4,100	1	--	--	1.1	1.3	0.5	0.22
Aroclor 1242	53469-21-9	33		--	--	--	--	230	1	--	--	--	--	0.5	0.0078
Aroclor 1248	12672-29-6	33		--	--	--	--	230	1	--	--	--	--	0.5	0.0078
Aroclor 1254	11097-69-1	33		--	1,600	500	--	240	1	--	--	0.32	0.044	0.5	0.0078
Aroclor 1260	11096-82-5	33		--	--	500	--	240	1	--	--	--	0.044	0.5	0.0078
Total PCBs	1336-36-3	33		1,000	--	500	--	230	1	--	0.10	--	0.044	0.5	0.5
SVOCs		CLP Low (µg/kg)	CLP SIM (µg/kg)	(µg/kg)					CLP Low (µg/L)	CLP SIM (µg/L)	(µg/L)				
1,1'-Biphenyl	92-52-4	170	--	--	40,000,000	130,000	--	47,000	5	--	--	4,000	5.5	--	0.83
2,2'-Oxybis(1-chloropropane)	108-60-1	330	--	--	3,200,000	14,000	--	3,100,000	10	--	--	320	0.63	--	710
2,3,4,6-Tetrachlorophenol	58-90-2	170	--	--	2,400,000	--	--	1,900,000	5	--	--	480	--	--	240
2,4,5-Trichlorophenol	95-95-4	170	--	--	8,000,000	--	1,500	6,300,000	5	--	--	800	--	--	1,200
2,4,6-Trichlorophenol	88-06-2	170	--	--	80,000	91,000	2.7	49,000	5	--	--	8	4	--	4.1
2,4-Dichlorophenol	120-83-2	170	--	--	240,000	--	10	190,000	5	--	--	24	--	--	46
2,4-Dimethylphenol	105-67-9	170	--	--	1,600,000	--	79	1,300,000	5	--	--	160	--	--	360
2,4-Dinitrophenol	51-28-5	330	--	--	160,000	--	9.2	130,000	10	--	--	32	--	--	39
2,4-Dinitrotoluene	121-14-2	170	--	--	160,000	3,200	0.11	1,700	5	--	--	32	0.28	--	0.24
2,6-Dinitrotoluene	606-20-2	170	--	--	24,000	670	0.021	360	5	--	--	4.8	0.058	--	0.049
2-Chloronaphthalene	91-58-7	170	--	--	6,400,000	--	--	4,800,000	5	--	--	640	--	--	750
2-Chlorophenol	95-57-8	170	--	--	40,000	--	27	390,000	5	--	--	40	--	--	91
2-Methylnaphthalene	91-57-6	170	3.3	--	320,000	--	--	240,000	5	0.1	--	32	--	--	36
2-Methylphenol	95-48-7	330	--	--	4,000,000	--	150	3,200,000	10	--	--	400	--	--	930
2-Nitroaniline	88-74-4	170	--	--	800,000	--	--	630,000	5	--	--	160	--	--	190
3,3'-Dichlorobenzidine	91-94-1	330	--	--	--	2,200	0.2	1,200	10	--	--	--	0.19	--	0.13
4-Chloroaniline	106-47-8	330	--	--	320,000	5,000	0.077	2,700	10	--	--	32	0.22	--	0.37
4-Methylphenol	106-44-5	330	--	--	8,000,000	--	--	6,300,000	10	--	--	800	--	--	1,900
Acenaphthene	83-32-9	170	3.3	--	4,800,000	--	5,000	3,600,000	5	0.1	--	960	--	--	530
Acetophenone	98-86-2	330	--	--	8,000,000	--	--	7,800,000	10	--	--	800	--	--	1,900
Anthracene	120-12-7	170	3.3	--	24,000,000	--	110000	18,000,000	5	0.1	--	4,800	--	--	1,800

Table 1-4 Regulatory Criteria and Screening Levels

Analyte	CAS #	Quantitation Limits by Method (See Table 1-3 for further details on analytical methods)		Soil					Quantitation Limits by Method (See Table 1-3 for further details on analytical methods)		Groundwater				
				MTCA A	MTCA B		Protective of GW (Saturated)	EPA Residential Soil RSL			MTCA A	MTCA B		EPA MCL	EPA Groundwater RSL
					Non-cancer	Cancer						Non-cancer	Cancer		
Atrazine	1912-24-9	330	--	--	2,800,000	4,300	--	2,400	10	--	--	560	0.38	--	0.3
Benzaldehyde	100-52-7	330	--	--	8,000,000	250,000	--	170,000	10	--	--	800	11	--	19
Benzo(a)anthracene*	56-55-3	170	3.3	--	--	--	43	1,100	5	0.1	--	--	0.12	--	0.03
Benzo(a)pyrene*	50-32-8	170	3.3	100	24,000	190	190	110	5	0.1	0.1	4.8	0.023	0.2	0.025
Benzo(b)fluoranthene*	205-99-2	170	3.3	--	--	--	150	1,100	5	0.1	--	--	0.12	--	0.25
Benzo(k)fluoranthene*	207-08-9	170	3.3	--	--	--	1500	1,100	5	0.1	--	--	1.20	--	2.5
Bis(2-Chloroethyl)ether	111-44-4	330	--	--	--	910	0.014	230	10	--	--	--	0.040	--	0.014
Bis(2-ethylhexyl)phthalate	117-81-7	170	--	--	1,600,000	71,000	670	39,000	5	--	--	320	6.3	6	5.6
Butylbenzylphthalate	85-68-7	170	--	--	16,000,000	530,000	650	290,000	5	--	--	3,200	46	--	16
Caprolactam	105-60-2	330	--	--	40,000,000	--	--	31,000,000	10	--	--	8,000	--	--	9,900
Chrysene	218-01-9	170	3.3	--	--		4,800	110,000	5	0.1	--	--	11.99	--	25
Dibenzo(a,h)anthracene*	53-70-3	170	3.3	--	--		21	110	5	0.1	--	--	0.012	--	0.025
Dibenzofuran	132-64-9	170	--	--	80,000	--	--	73,000	5	--	--	16	--	--	7.90
Diethylphthalate	84-66-2	170	--	--	64,000,000	--	4,700	51,000,000	5	--	--	13,000	--	--	15,000
Di-n-butylphthalate	84-74-2	170	--	--	8,000,000	--	3,000	6,300,000	5	--	--	1,600	--	--	900
Di-n-octylphthalate	117-84-0	330	--	--	800,000	--	13,000,000	630,000	10	--	--	160	--	--	200
Dioxane, 1,4-	123-91-1	67	--	--	2,400,000	10,000	--	5,300	2	--	--	240	0.44	--	0.46
Fluoranthene	206-44-0	330	3.3	--	3,200,000	--	32,000	2,400,000	10	0.1	--	640	--	--	800
Fluorene	86-73-7	170	3.3	--	3,200,000	--	5,100	2,400,000	5	0.1	--	640	--	--	290
Hexachlorobenzene	118-74-1	170	--	--	64,000	630	44	210	5	--	--	13	0.055	1	0.0098
Hexachlorocyclopentadiene	77-47-4	330	--	--	480,000	--	9,600	1,800	10	--	--	48	--	50	0.41
Hexachloroethane	67-72-1	170	--	--	56,000	25,000	2.3	1,800	5	--	--	5.6	1.1	--	0.33
Indeno(1,2,3-cd)pyrene*	193-39-5	170	3.3	--	--		420	1,100	5	0.1	--	--	0.12	--	0.25
Isophorone	78-59-1	170	--	--	16,000,000	1100000	15	570,000	5	--	--	1,600	46	--	78
Naphthalene*	91-20-3	170	3.3	5,000	1,600,000	--	240	3,800	5	0.1	160	160	--	--	0.17
Nitrobenzene	98-95-3	170	--	--	160,000	--	6.5	5,100	5	--	--	16	--	--	0.14
N-Nitroso-di-n-propylamine	621-64-7	170	--	--	--	140	0.0039	78	5	--	--	--	0.013	--	0.011
N-Nitrosodiphenylamine	86-30-6	170	--	--	--	200,000	28	110,000	5	--	--	--	18	--	12
Pentachlorophenol*	87-86-5	330	6.7	--	400,000	2,500	0.88	1,000	10	0.2	--	80	0.22	1	0.041
Phenol	108-95-2	330	--	--	24,000,000	--	760	19,000,000	10	--	--	2,400	--	--	5,800
Pyrene	129-00-0	170	3.3	--	2,400,000	--	33,000	1,800,000	5	0.1	--	480	--	--	120
VOCs		**CLP Low (µg/kg)**	**--**	**(µg/kg)**					**CLP Low (µg/L)**	**CLP Trace (µg/L)**	**(µg/L)**				
1,1,1-Trichloroethane	71-55-6	5	--	2,000	160,000,000	--	84	8,100,000	5	0.5	200	16,000	--	200	8,000
1,1,2,2-Tetrachloroethane*	79-34-5	5	--	--	1,600,000	5,000	0.08	600	5	0.5	--	160	0.22	--	0.076
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5	--	--	2,400,000,000	--	--	6,700,000	5	0.5	--	240,000	--	--	10,000
1,1,2-Trichloroethane*	79-00-5	5	--	--	320,000	18,000	1.8	1,100	5	0.5	--	32	0.77	5	0.28
1,1-Dichloroethane	75-34-3	5	--	--	16,000,000	180,000	2.6	3,600	5	0.5	--	1,600	7.7	--	2.8
1,1-Dichloroethene	75-35-4	5	--	--	4,000,000	--	2.5	230,000	5	0.5	--	400	--	7	280
1,2,4-Trichlorobenzene*	120-82-1	5	--	--	800,000	34,000	29	24,000	5	0.5	--	80	1.5	70	1.2
1,2-Dibromo-3-chloropropane*	96-12-8	5	--	--	16,000	1,300	--	5.3	5	0.5	--	1.6	0.055	0.2	0.00033
1,2-Dibromoethane*	106-93-4	5	--	5	720,000	500	--	36	5	0.5	0.01	72	0.022	0.05	0.0075
1,2-Dichlorobenzene	95-50-1	5	--	--	7,200,000	--	400	1,800,000	5	0.5	--	720	--	600	300
1,2-Dichloroethane*	107-06-2	5	--	--	480,000	11,000	1.6	460	5	0.5	5	48	0.48	5	0.17
1,2-Dichloropropane	78-87-5	5	--	--	3,200,000	27,000	1.7	2,500	5	0.5	--	320	1.2	5	0.85
1,4-Dichlorobenzene*	106-46-7	5	--	--	5,600,000	190,000	68	2,600	5	0.5	--	560	8.1	75	0.48
2-Butanone	78-93-3	10	--	--	48,000,000	--	--	27,000,000	10	5	--	4,800	--	--	5,600
4-Methyl-2-pentanone	108-10-1	10	--	--	6,400,000	--	--	33,000,000	10	5	--	640	--	--	6,300
Acetone	67-64-1	10	--	--	72,000,000	--	2100	61,000,000	10	5	--	7,200	--	--	14,000

Table 1-4 Regulatory Criteria and Screening Levels

Analyte	CAS #	Soil: Quantitation Limits by Method (See Table 1-3 for further details on analytical methods)		Soil: MTCA A	Soil: MTCA B Non-cancer	Soil: MTCA B Cancer	Soil: MTCA B Protective of GW (Saturated)	Soil: EPA Residential Soil RSL	Groundwater: Quantitation Limits by Method (See Table 1-3 for further details on analytical methods)		Groundwater: MTCA A	Groundwater: MTCA B Non-cancer	Groundwater: MTCA B Cancer	Groundwater: EPA MCL	Groundwater: EPA Groundwater RSL
Benzene*	71-43-2	5	--	30	320,000	18,000	1.7	1,200	5	0.5	5	32	0.80	5	0.46
Bromodichloromethane*	75-27-4	5	--	--	1,600,000	16,000	2.6	290	5	0.5	--	160	0.71	80	0.13
Bromoform	75-25-2	5	--	--	1,600,000	130,000	23	19,000	5	0.5	--	160	5.5	80	3.3
Bromomethane	74-83-9	5	--	--	--	--	--	6,800	5	0.5	--	11	--	--	7.5
Carbon disulfide	75-15-0	5	--	--	8,000,000	--	270	770,000	5	0.5	--	800	--	--	810
Carbon tetrachloride*	56-23-5	5	--	--	320,000	14,000	2.2	650	5	0.5	--	32	0.63	5	0.46
Chlorobenzene	108-90-7	5	--	--	1,600,000	--	51	280,000	5	0.5	--	160	--	100	78
Chloroform*	67-66-3	5	--	--	800,000	32,000	4.8	320	5	0.5	--	80	1.4	80	0.22
Chloromethane	74-87-3	5	--	--	--	--	--	110,000	5	0.5	--	--	--	--	190
cis-1,2-Dichloroethene	156-59-2	5	--	--	1,600,000	--	5.2	160,000	5	0.5	--	16	--	70	36
Dibromochloromethane	124-48-1	5	--	--	1,600,000	12,000	1.8	8,300	5	0.5	--	160	0.52	80	0.87
Dichlorodifluoromethane	75-71-8	5	--	--	16,000,000	--	--	87,000	5	0.5	--	1,600	--	--	200
Ethylbenzene	100-41-4	5	--	6,000	8,000,000	--	340	5,800	5	0.5	700	800	--	700	1.5
Isopropylbenzene	98-82-8	5	--	--	8,000,000	--	--	1,900,000	5	0.5	--	800	--	--	450
Methyl acetate	79-20-9	5	--	--	80,000,000	--	--	78,000,000	5	0.5	--	8,000	--	--	20,000
Methyl tert-butyl ether	1634-04-4	5	--	100	--	560,000	7.2	47,000	5	0.5	20	--	24	--	14
Methylene chloride	75-09-2	5	--	20	480,000	500,000	1.5	57,000	5	0.5	5	48	22	5	11
Styrene	100-42-5	5	--	--	16,000,000	--	120	6,000,000	5	0.5	--	1,600	--	100	1,200
Tetrachloroethene	127-18-4	5	--	50	480,000	480,000	2.8	24,000	5	0.5	5	48	21	5	11
Toluene	108-88-3	5	--	7,000	6,400,000	--	270	4,900,000	5	0.5	1000	640	--	1000	1,100
trans-1,2-Dichloroethene	156-60-5	5	--	--	1,600,000	--	32	1,600,000	5	0.5	--	160	--	100	360
Trichloroethylene*	79-01-6	5	--	30	40,000		1.5	940	5	0.5	5	4		5	0.49
Trichlorofluoromethane	75-69-4	5	--	--	24,000,000	--	--	23,000,000	5	0.5	--	2,400	--	--	5,200
Vinyl chloride*	75-01-4	5	--	--	240,000	--	0.08	59	5	0.5	0.2	24	--	2	0.019
Xylene, m-	108-38-3	5[e]	--	--	16,000,000	--	770	550,000	5[e]	0.5[e]	--	1,600	--	--	190
Xylene, mixture	1330-20-7	5[e]	--	9,000	16,000,000	--	830	580,000	5[e]	0.5[e]	1,000	1,600	--	10000	190
Xylene, o-	95-47-6	5[e]	--	--	16,000,000	--	840	650,000	5[e]	0.5[e]	--	1,600	--	--	190
Xylene, p-	106-42-3	5[e]	--	--	16,000,000	--	960	560,000	5[e]	0.5[e]	--	1,600	--	--	190
TPH		**NWTPH (mg/kg)**		**(mg/kg)**					**NWTPH (µg/L)**		**(µg/L)**				
Gasoline	None	5		30[c]/100[d]	--	--	--	--	250		800[c]/1,000[d]	--	--	--	--
Diesel	None	25		2,000	--	--	--	--	250		500	--	--	--	--
Heavy oil	64742-65-0	100		2,000	--	--	--	--	500		500	--	--	--	--

Note:

* Inorganic analytes will receive ICP-MS analysis and organic analytes will receive SIM analysis to meet or come as close as possible to established regulatory criteria.

a = Value is for Chromium III

b = Value is EPA MCL

c = If benzene is present

d = If benzene is not present

e = Value for m,p-xylene used

Key:

-- = No associated cleanup level or value.

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

CAS = Chemical Abstracts Service

CLP = Contract Laboratory Program

GW = Groundwater

ICP-AES = Inductively coupled plasma atomic emission spectroscopy

ICP-MS = Inductively coupled plasma mass spectrometry

MCL = National Primary Drinking Water maximum contaminant level

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

MTCA = Model Toxics Control Act

NWTPH = Northwest Total Petroleum Hydrocarbon

PCBs = Polychlorinated biphenyls

RSL = Residential screening level

SVOCs = Semivolatile organic compounds

TPH = Total petroleum hydrocarbons

VOCs = Volatile organic compounds

Table 1-5 Proposed Schedule

Activity	Start Date	Completion Date
Collect pertinent background information	June 2019	September 2019
Mobilize to the site	October 21, 2019	October 21, 2019
Sample collection activities	October 21, 2019	October 22, 2019
Laboratory receipt of samples	October 23, 2019	October 24, 2019
Demobilization from the site	October 22, 2019	October 22, 2019
Laboratory analysis	October 24, 2019	November 21, 2019
Data validation	November 21, 2019	December 23, 2019
Writing of the draft project report	October 25, 2019	February 10, 2020
Responding to EPA comments and submittal of final report	February 24, 2020	March 9, 2020
Target project completion date	March 10, 2010	March 31, 2010

Table 3-1 Sample Coding

Digits	Description	Code	Example
1,2	Source Code	BH	Borehole
		MW	Monitoring well
		RI	Rinsate
		TB	Trip Blank
		ID	Investigation Derived Waste
3,4	Consecutive Number	01	First number of source code
5,6	Matrix Code	GW	Groundwater
		SB	Subsurface Soil
		WT	Water
7,8	Consecutive Number	01	Subsurface soil sampling interval

Figures

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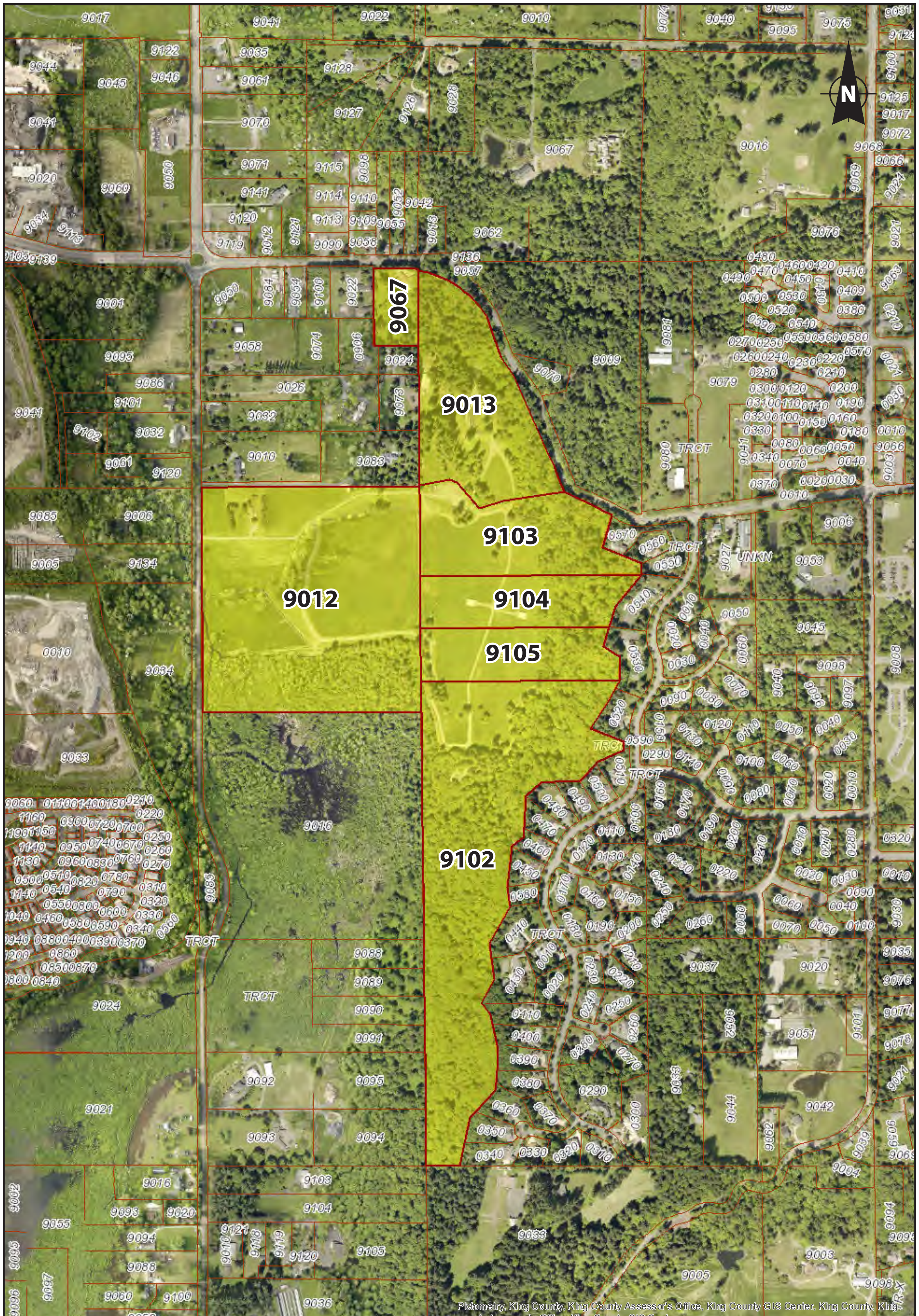
Seattle, Washington

GUNSHY MANOR
Redmond, Washington

Figure 1-1
Site Vicinity Map

0 .5 1
Approximate Scale in Miles

Date:	Drawn by:	
9-27-19	AGM	02:1004530.0027.009.01



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Redmond, Washington

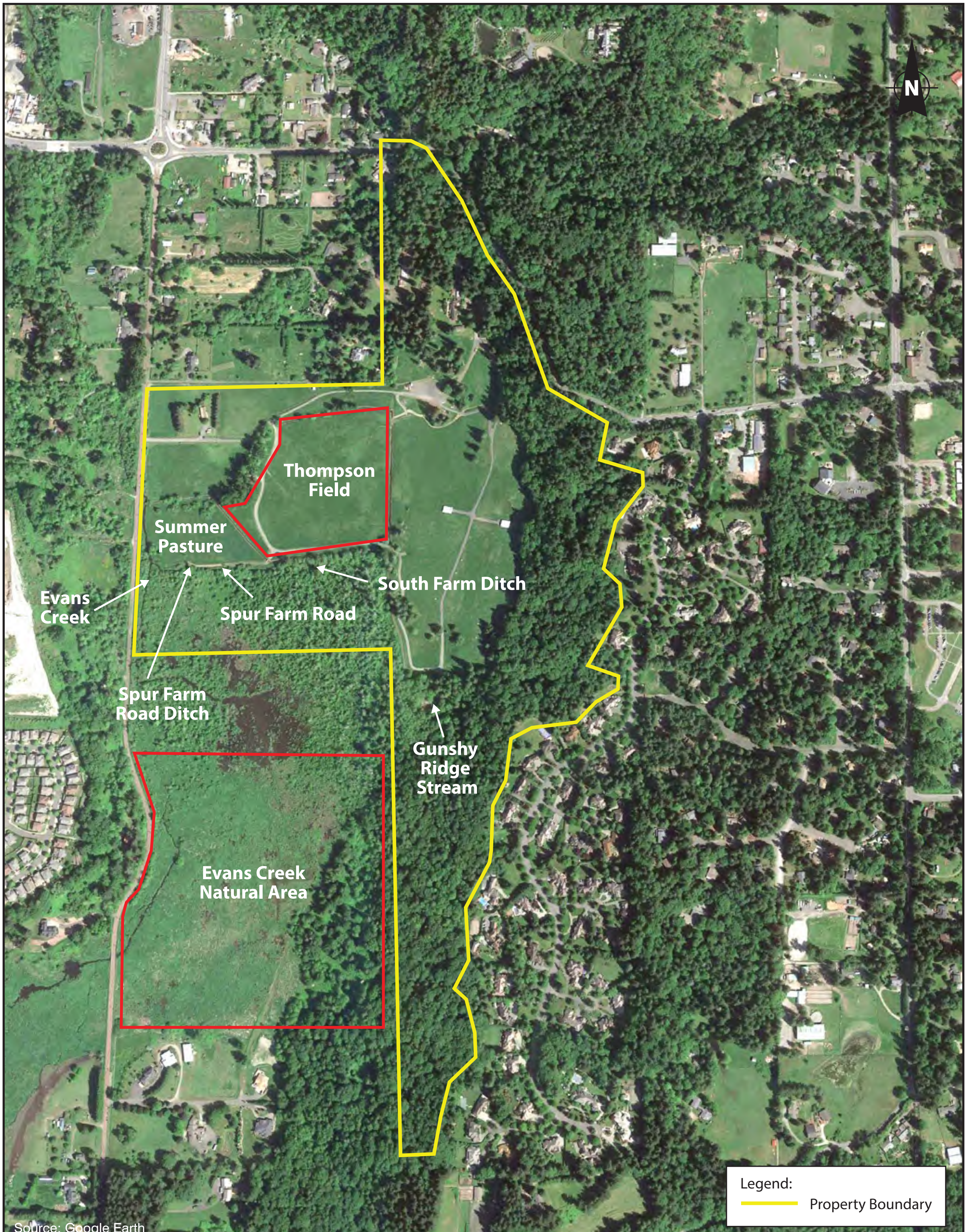
0 400 800
Approximate Scale in Feet

Figure 1-2
Site Parcel Map

Date:
9-27-19

Drawn by:
AGM

02:1004530.0027.009.01



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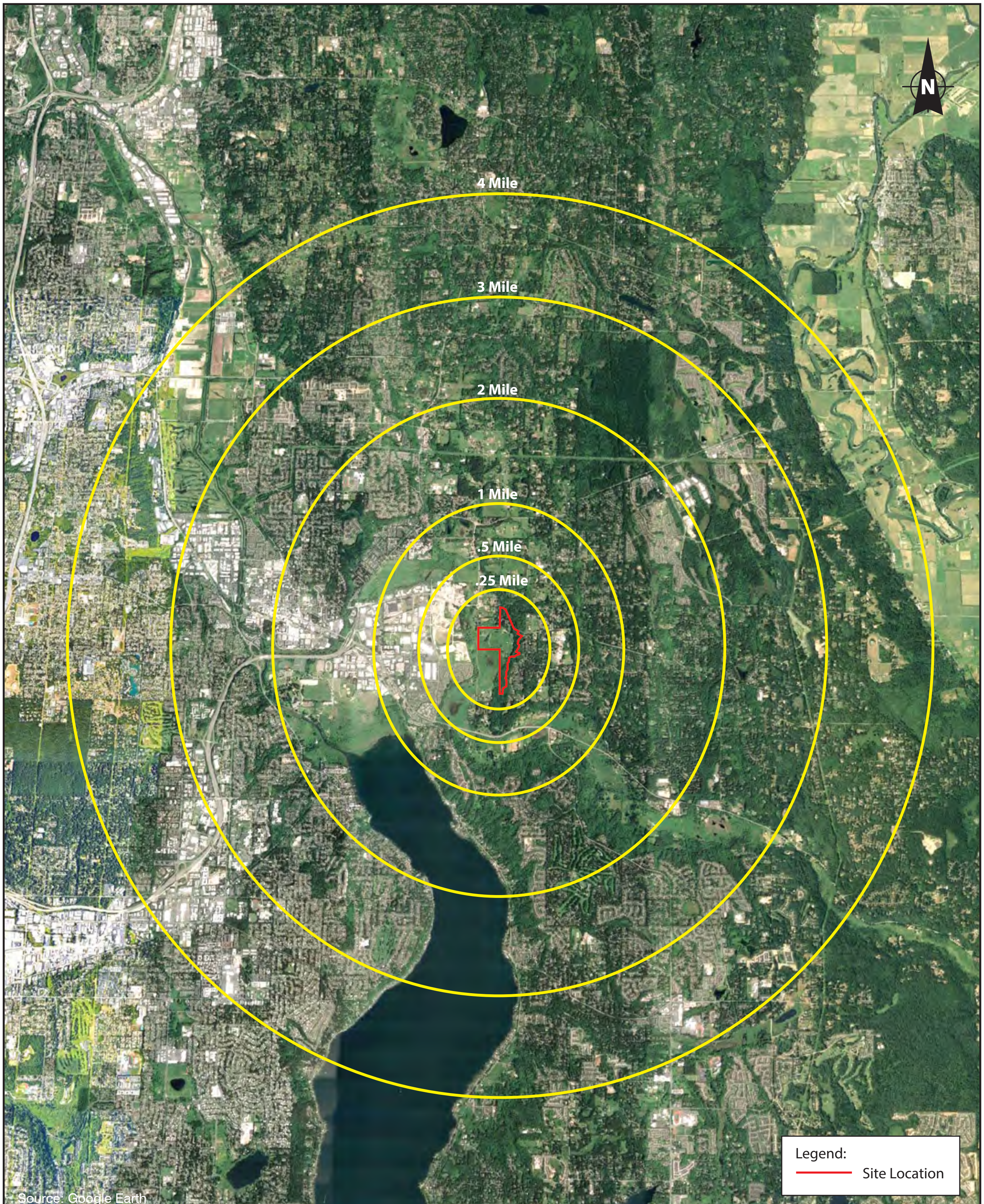
0 400 800
Approximate Scale in Feet

Figure 1-3
Site Map

Date:	Drawn by:	
9-27-19	AGM	02:1004530.0027.009.01



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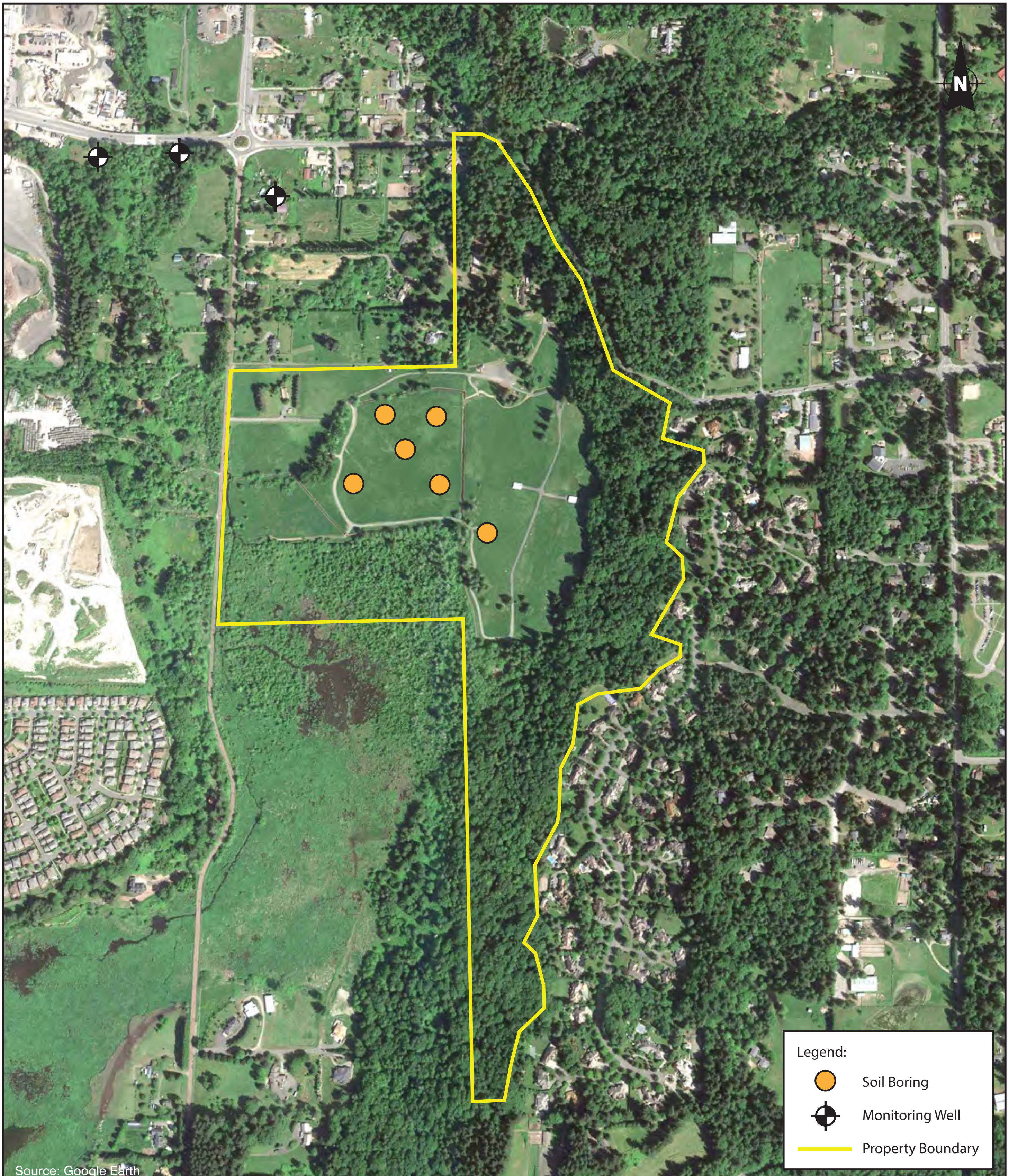
GUNSHY MANOR
Redmond, Washington

Figure 1-4
4-Mile Map

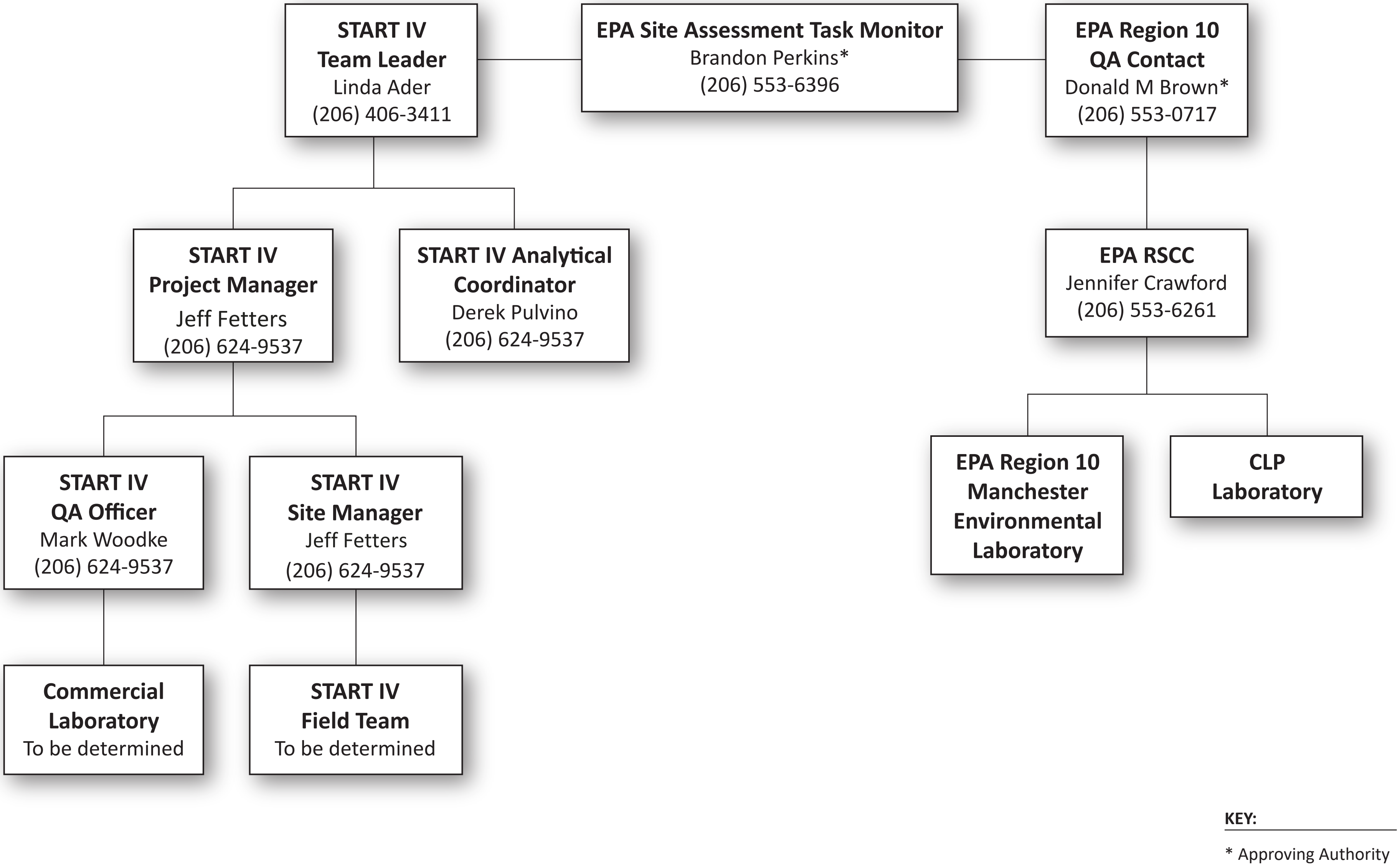
Date: 9-27-19

Drawn by: AGM

02:1004530.0027.009.01



ecology and environment, inc. Global Environmental Specialists Seattle, Washington	GUNSHY MANOR Redmond, Washington	Figure 1-5 Proposed Sample Locations
	0 400 800 Approximate Scale in Feet	Date: 9-27-19 / Drawn by: AGM / 02:1004530.0027.009.01



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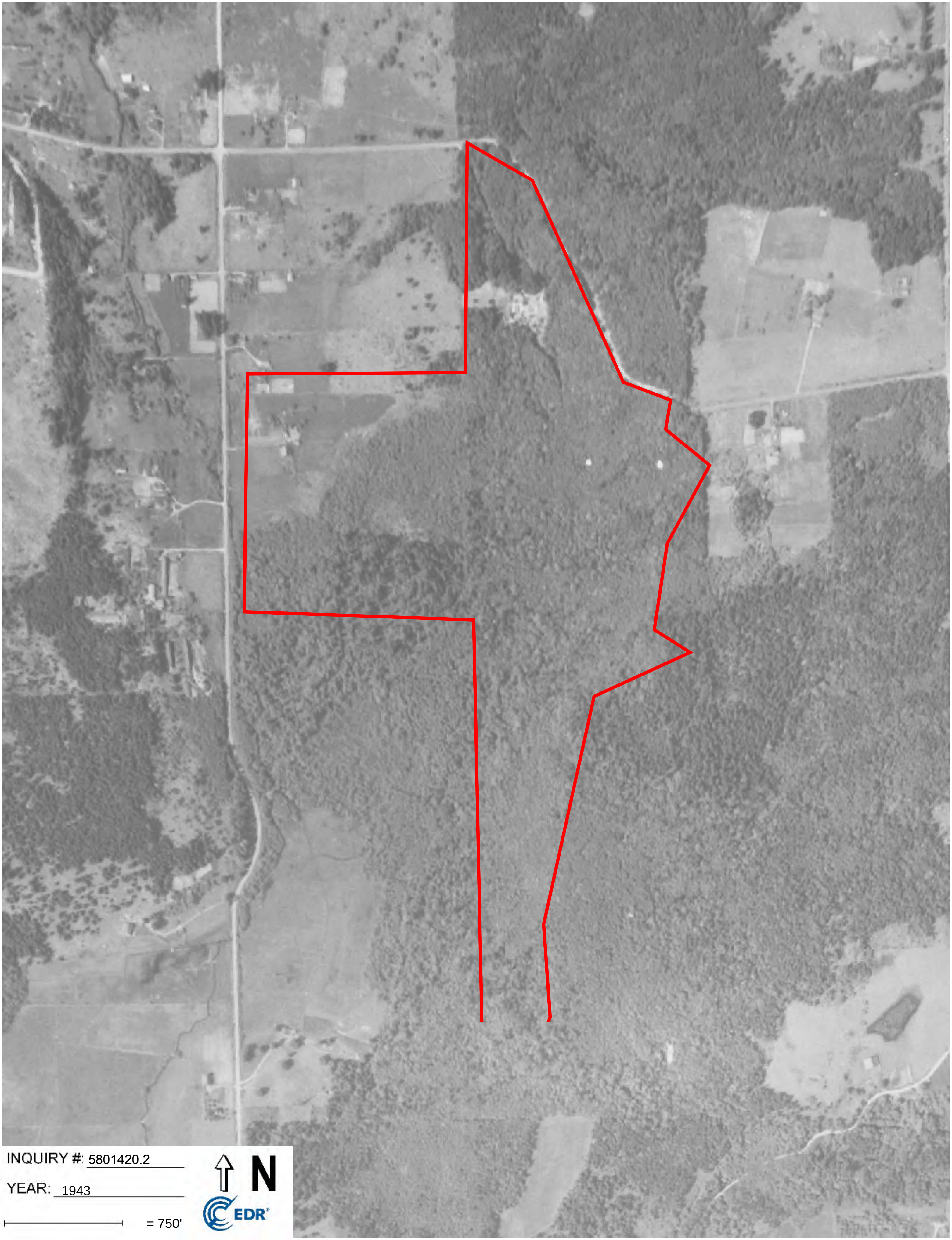
GUNSHY MANOR
Redmond, Washington

Figure 2-1
PROJECT ORGANIZATION CHART

Date:	Drawn by:	
09/23/19	LEA	10:START-IV\T27-009\fig 2-1

Chapter A

A Historic Aerial Photographs



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YEAR: 1943

= 750'

N

EDR

INQUIRY #: 5801420.2

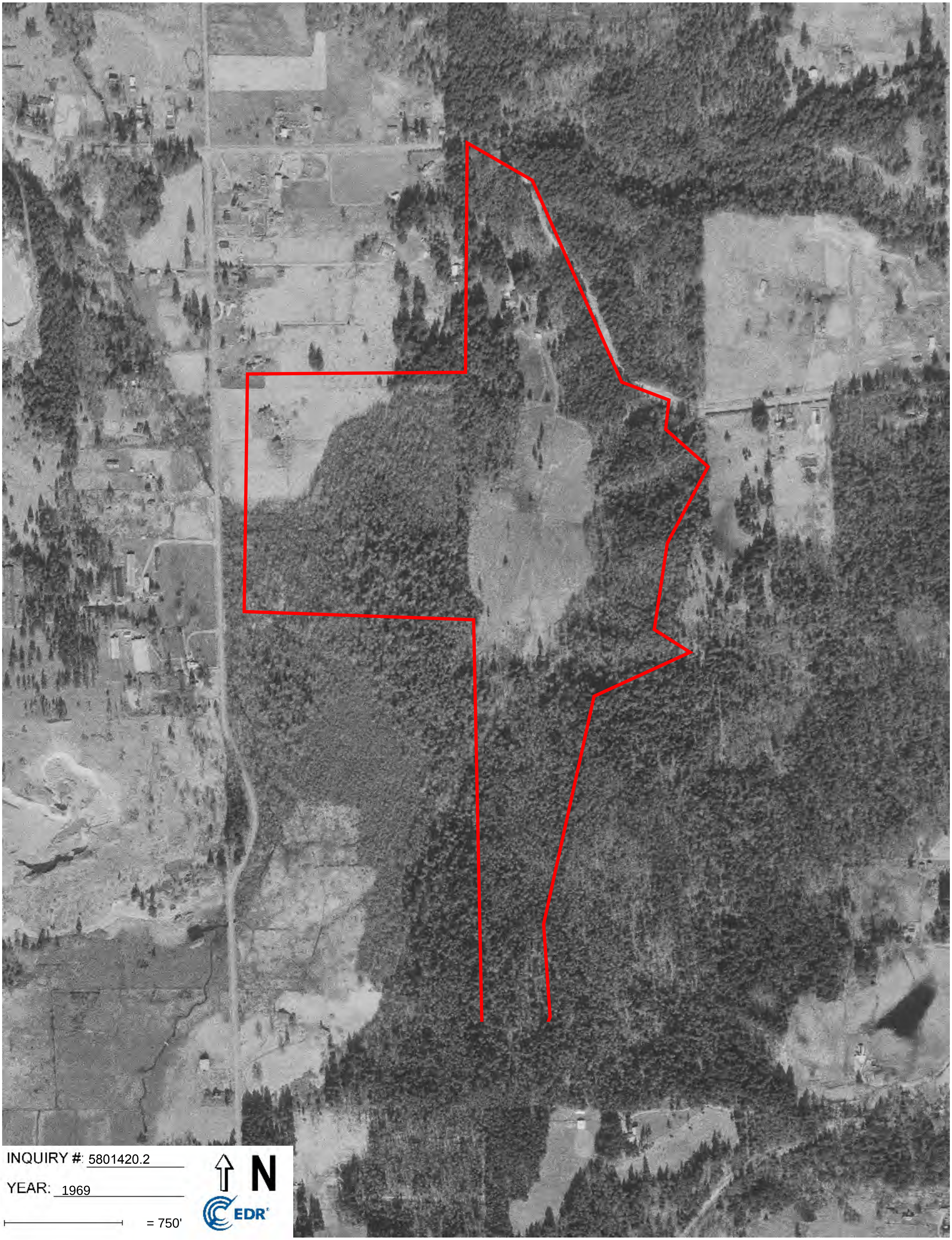
YEAR: 1965

= 750'

N

EDR

Subject boundary not shown because it exceeds image extent or image is not georeferenced.



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YEAR: 1969

= 750'

N

EDR

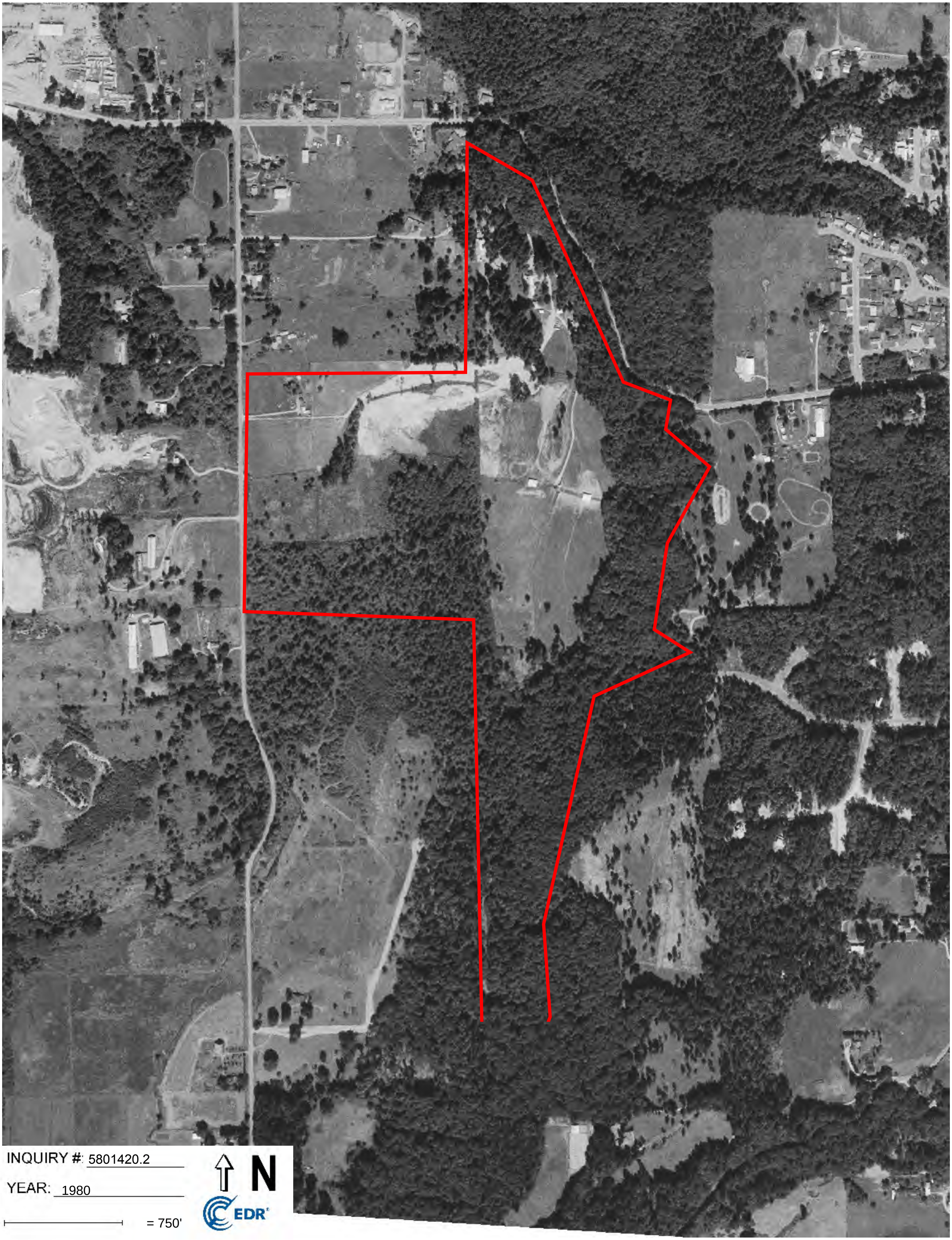
INQUIRY #: 5801420.2

YEAR: 1977

= 750'

N

EDR



INQUIRY #: 5801420.2

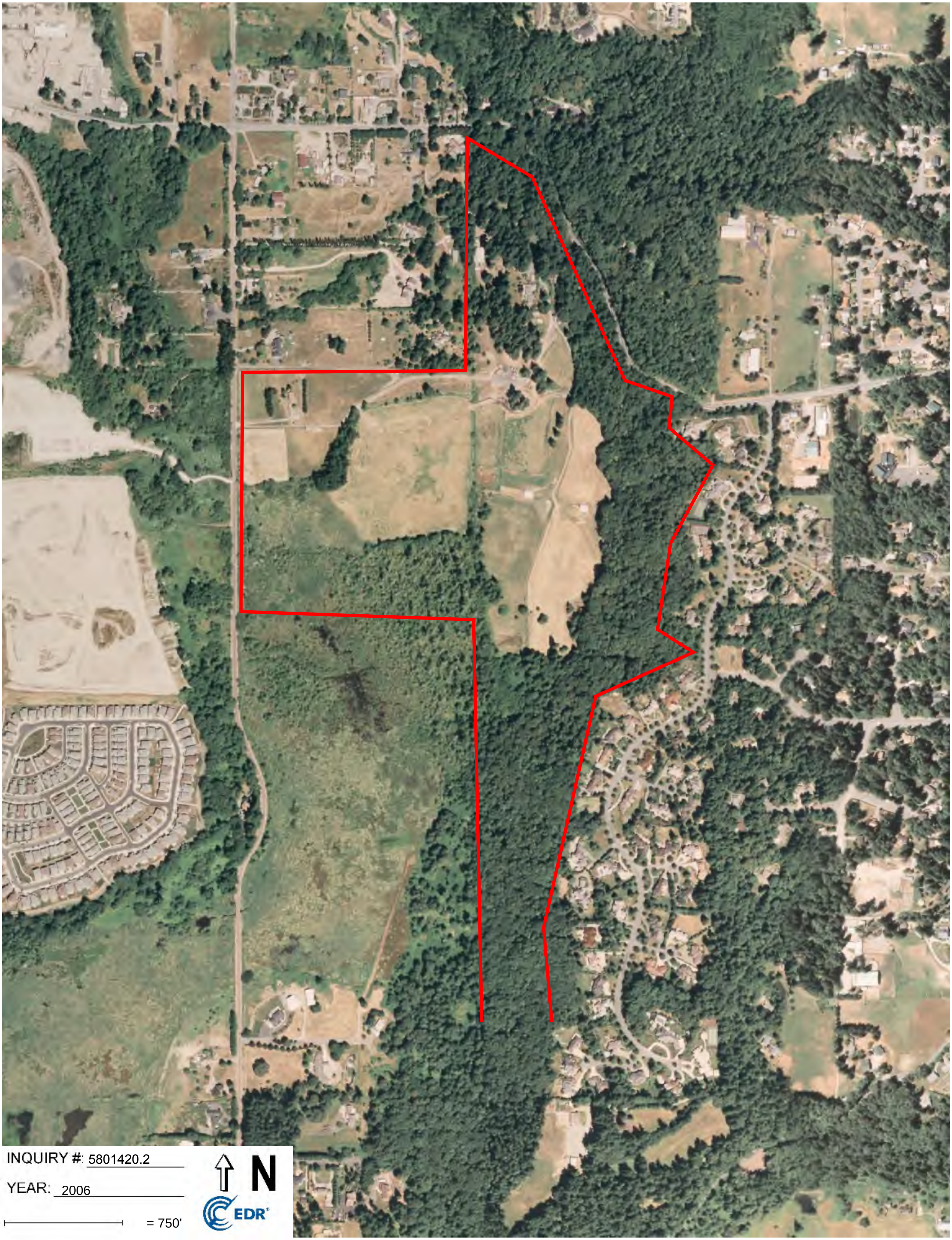
YEAR: 1980

= 750'

N

EDR


INQUIRY #: 5801420.2
YEAR: 1990
= 750'
N
EDR



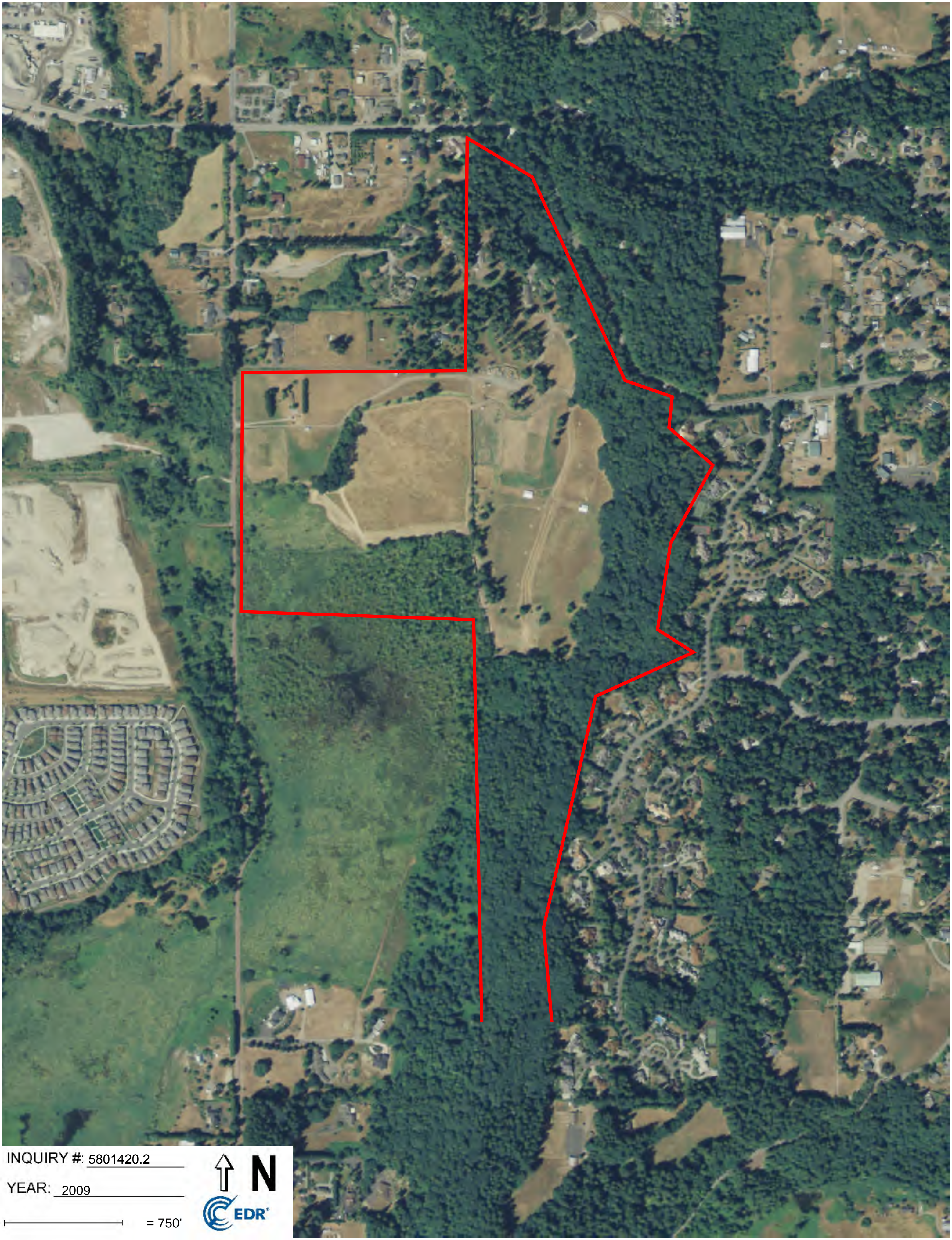
INQUIRY #: 5801420.2

YEAR: 2006

= 750'

N

EDR



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YEAR: 2009

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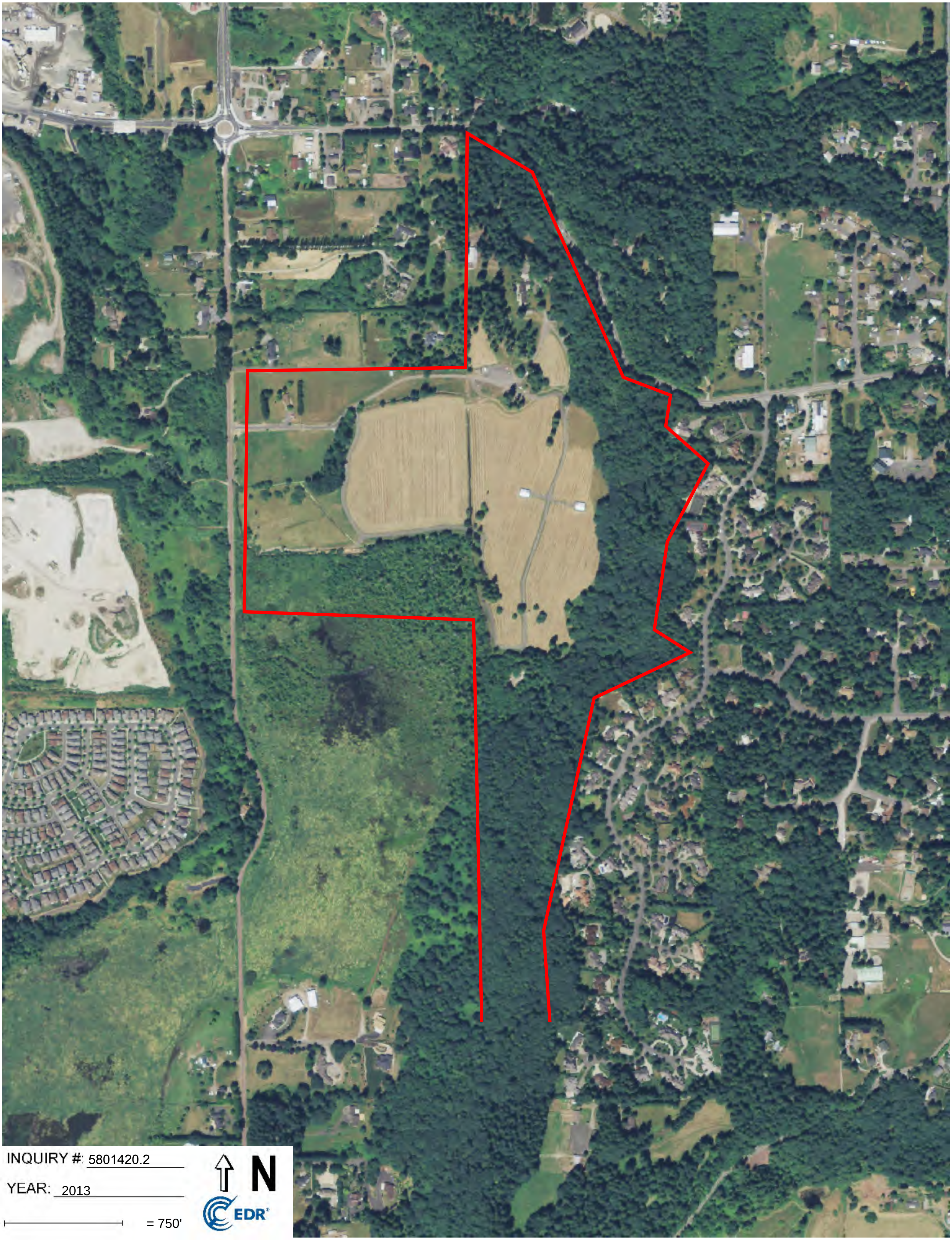
N

EDR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YEAR: 2013
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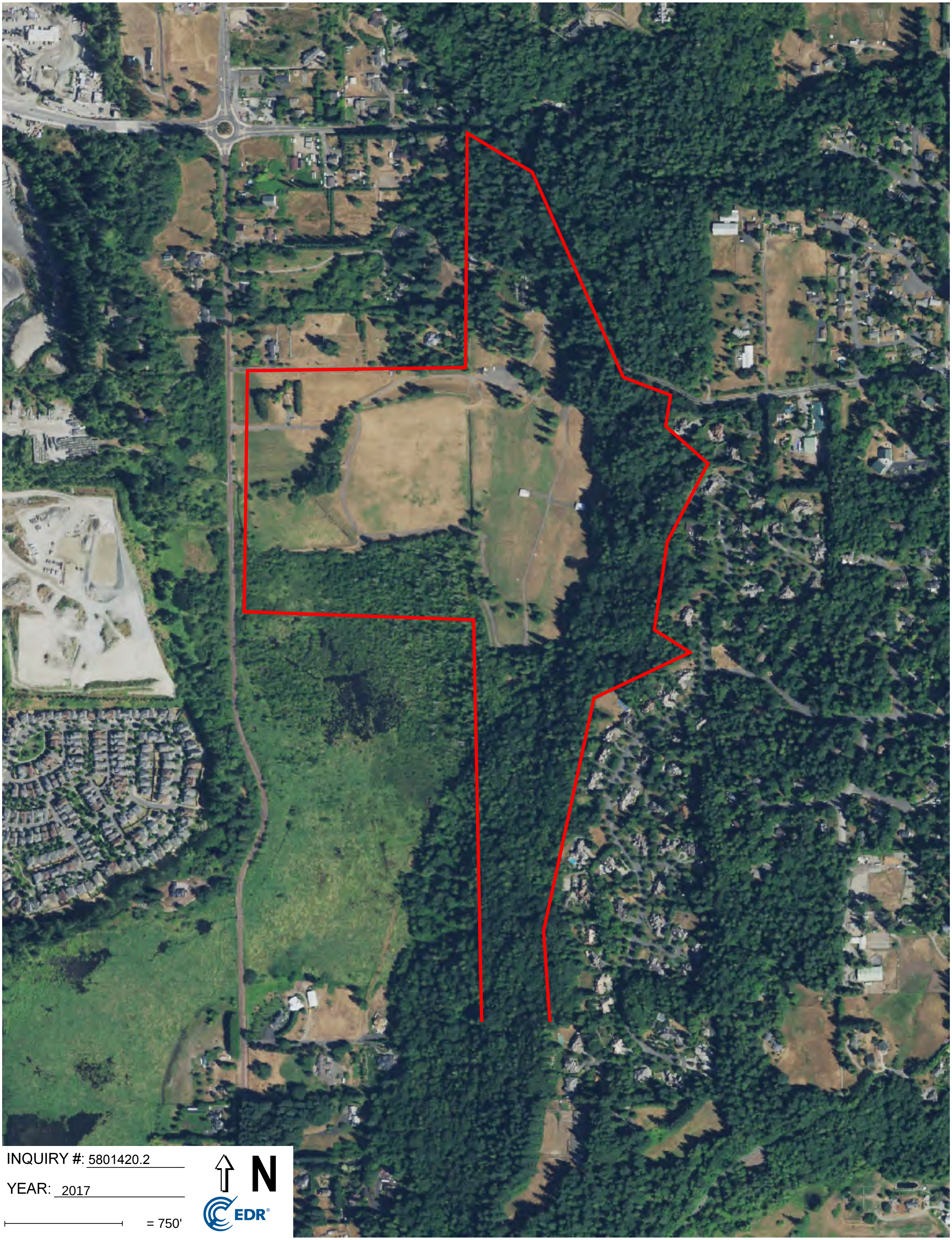
N
EDR


INQUIRY #: 5801420.2
YEAR: 2017
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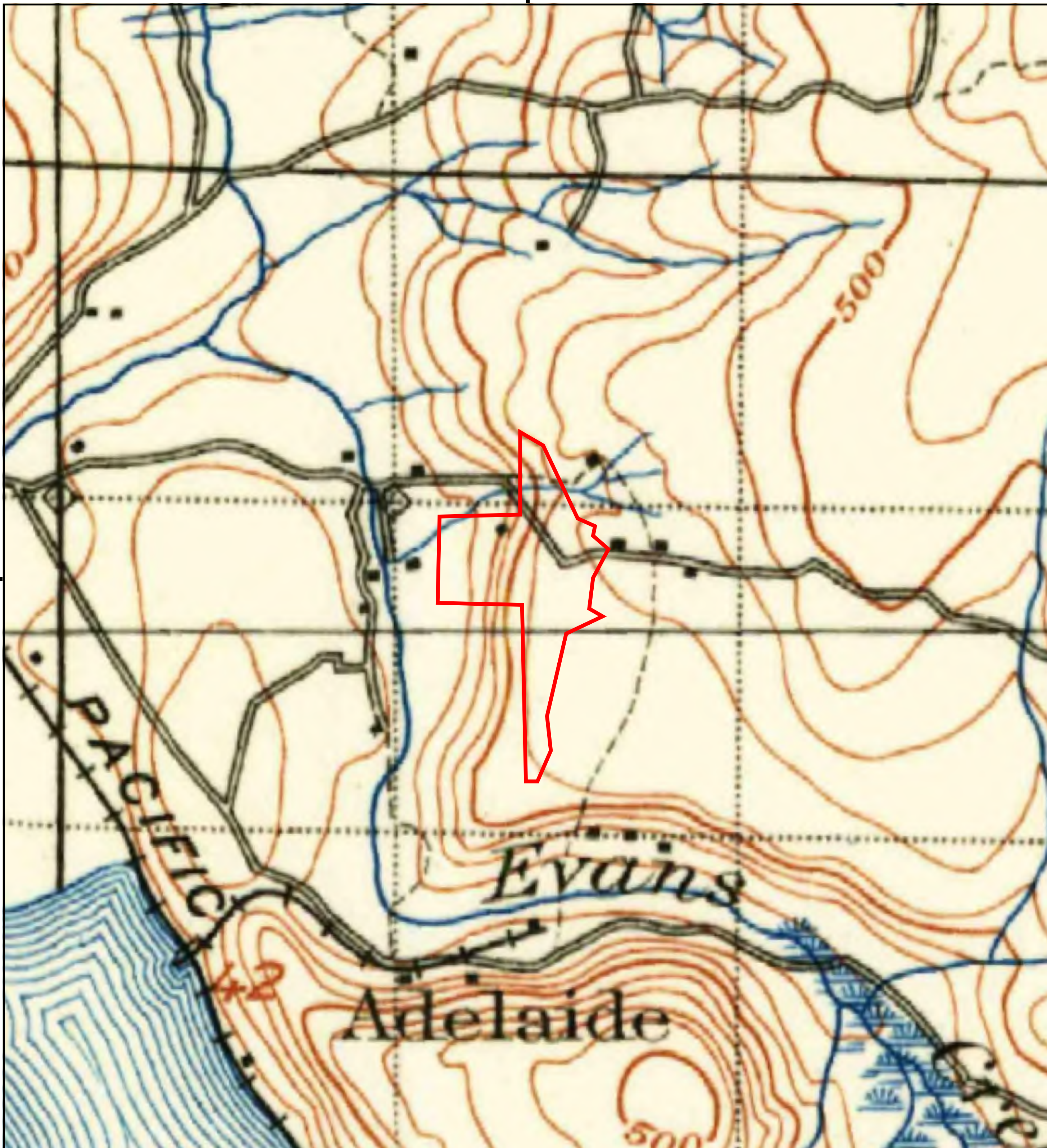
EDR

Chapter B

B Historic Topographic Maps

Historical Topo Map

1895



This report includes information from the following map sheet(s).

0 Miles 0.25 0.5 1 1.5

NW N NE
W E
SW S SE

TP, Snohomish, 1895, 30-minute

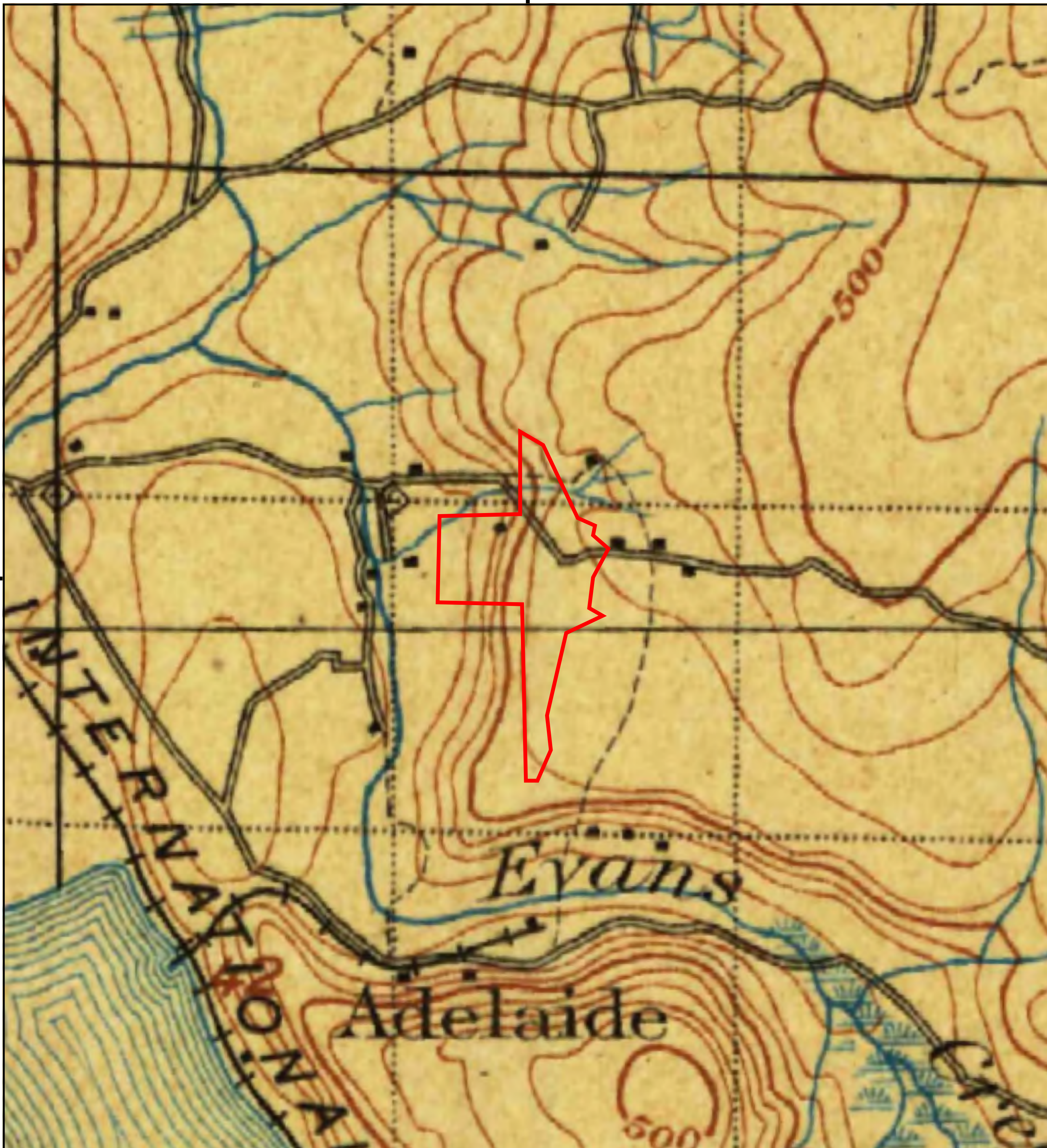
SITE NAME: Gunshy Manor
ADDRESS: 7240 196th Ave NE
Redmond, WA 98053
CLIENT: Ecology and Environment

N

EDR

Historical Topo Map

1897



This report includes information from the following map sheet(s).

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W E
SW S SE

TP, Seattle, 1897, 30-minute
TP, Snohomish, 1897, 30-minute

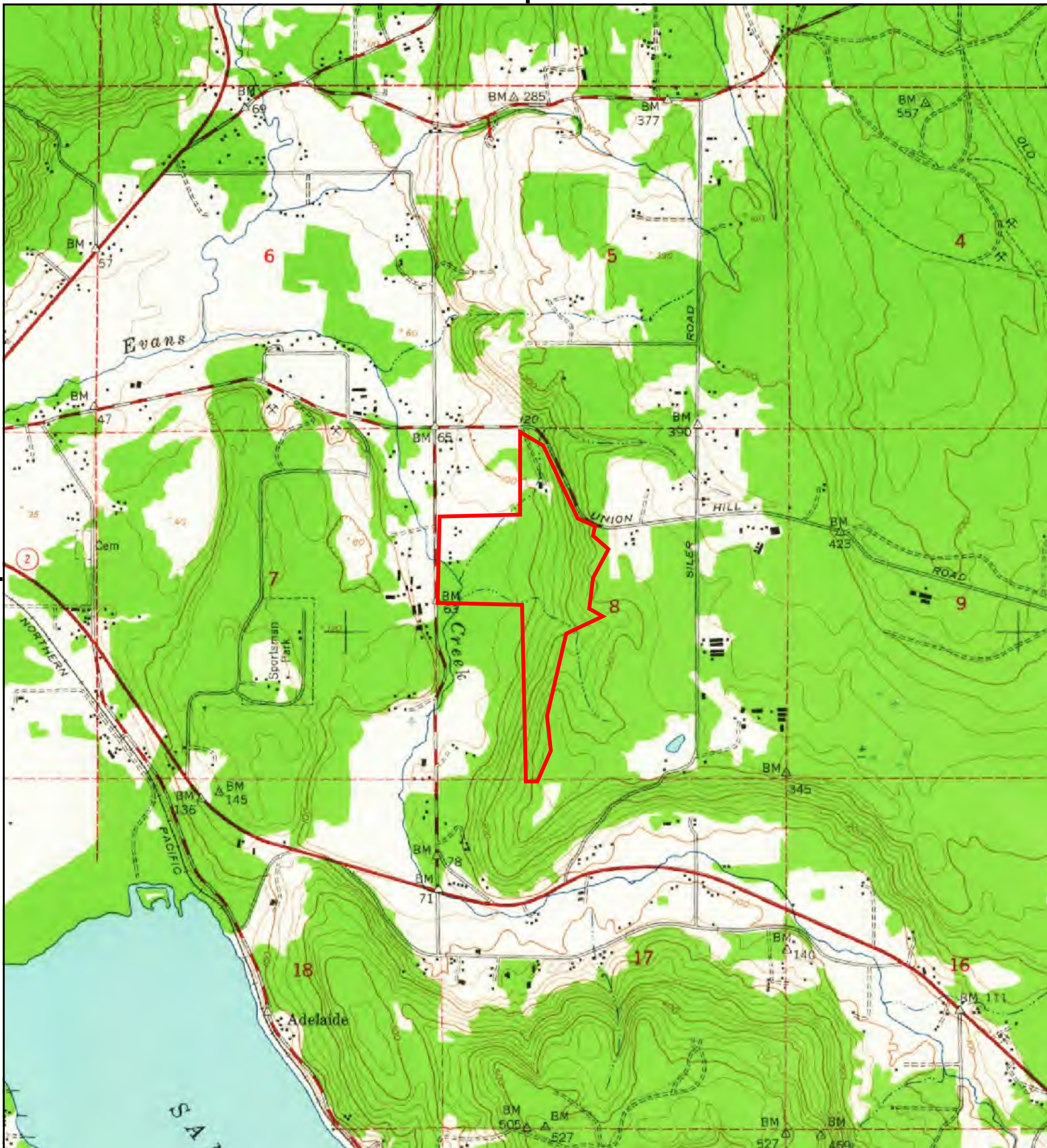
SITE NAME: Gunshy Manor
ADDRESS: 7240 196th Ave NE
Redmond, WA 98053
CLIENT: Ecology and Environment

N

5801420 - 1

Historical Topo Map

1950



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W E

SW S SE

TP, Redmond, 1950, 7.5-minute

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ADDRESS: 7240 196th Ave NE
Redmond, WA 98053

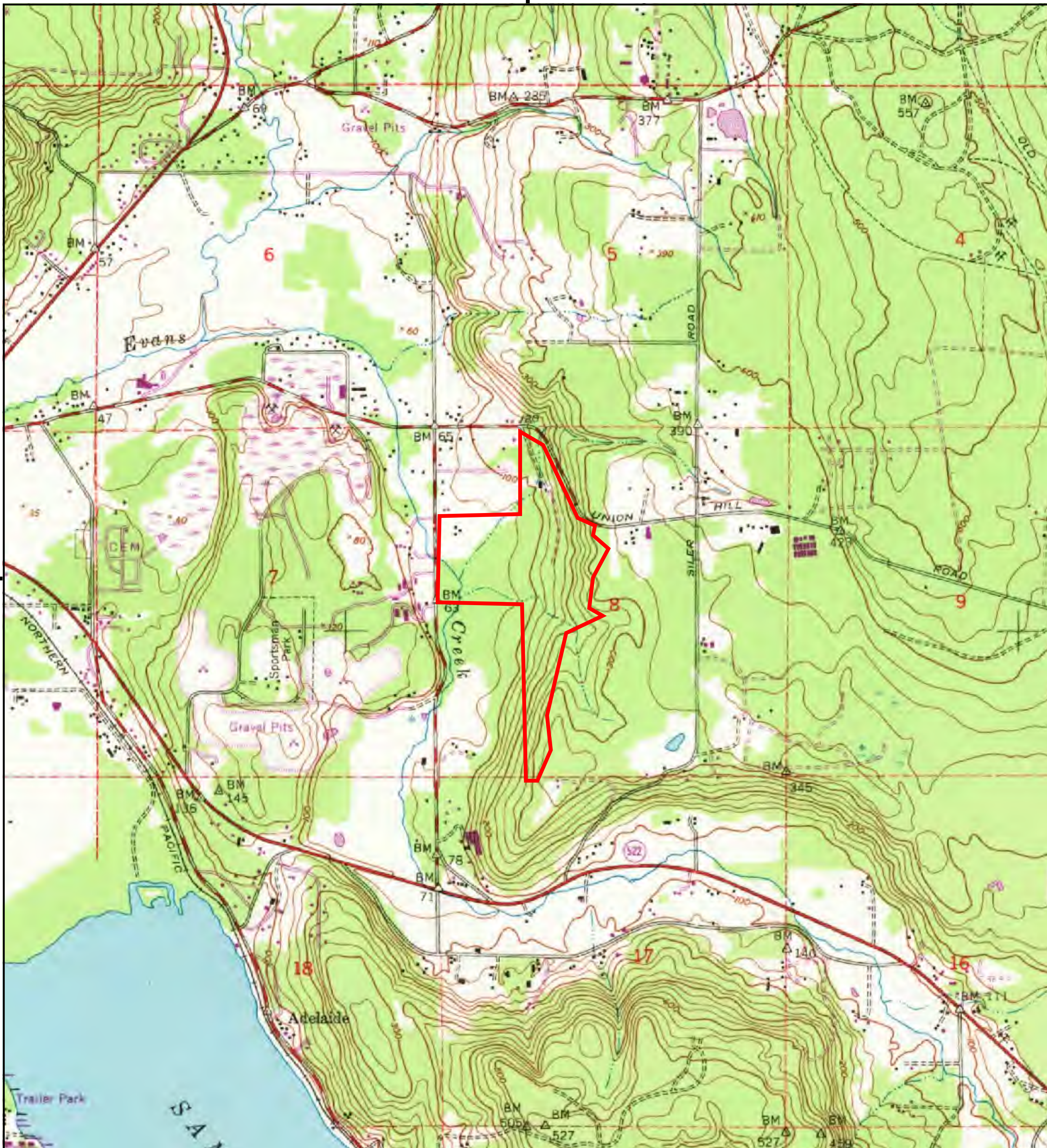
CLIENT: Ecology and Environment

N

5801420 - 1 p

Historical Topo Map

1968



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W E
SW S SE

TP, Redmond, 1968, 7.5-minute

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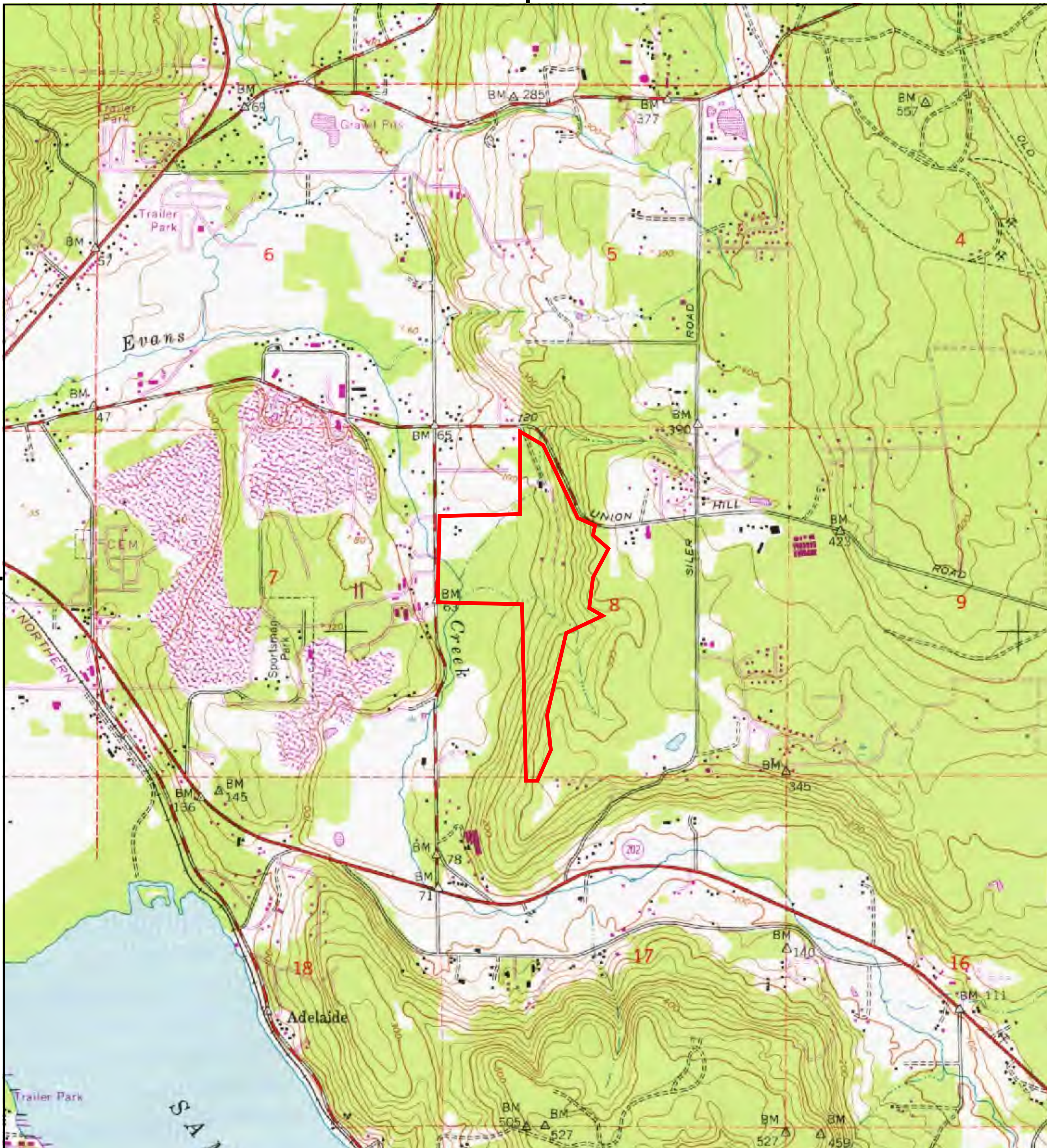
ADDRESS: 7240 196th Ave NE
Redmond, WA 98053
CLIENT: Ecology and Environment

N

Historical Topo Map

1973



0 Miles	0.25	0.5	1	1.5

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NW N NE

W E

SW S SE

TP, Redmond, 1973, 7.5-minute

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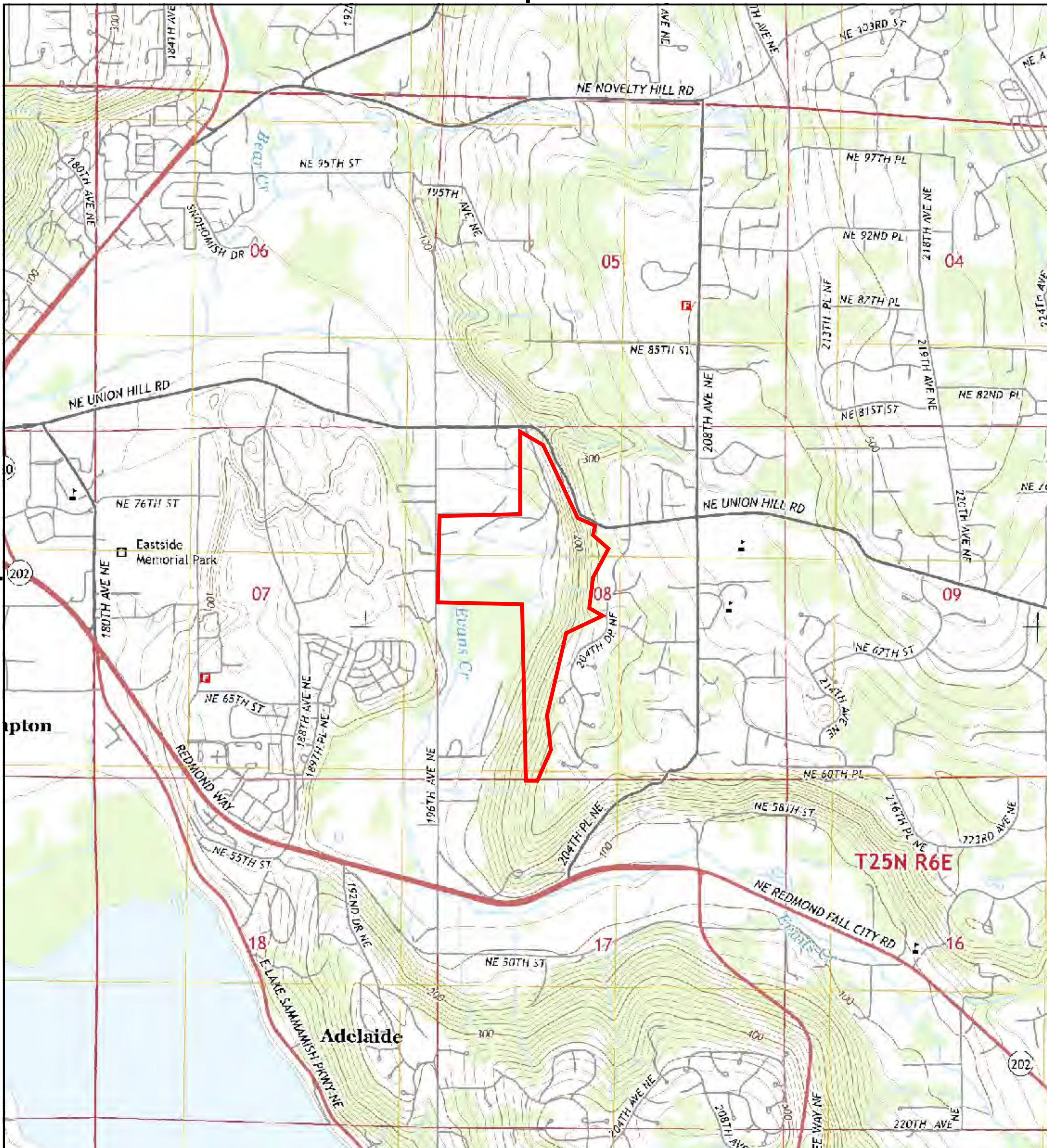
ADDRESS: 7240 196th Ave NE
Redmond, WA 98053
CLIENT: Ecology and Environment

N

Historical Topo Map

2014



This report includes information from the following map sheet(s).

0 Miles 0.25 0.5 1 1.5

NW N NE
W E
SW S SE

TP, Redmond, 2014, 7.5-minute

SITE NAME: Gunshy Manor
ADDRESS: 7240 196th Ave NE
Redmond, WA 98053
CLIENT: Ecology and Environment

N

Chapter C

C Sample Plan Alteration Form

SAMPLE PLAN ALTERATION FORM
(QAPP Addendum – SPAF # NN)

QAPP Title, Author (company), Revision, and Approval Date of standing 'parent' QAPP:

Project Name and assigned Region 10 Project Code:

Material to be Sampled:

Measurement Parameters:

Standard Procedure for Field Collection and Laboratory Analysis (cite references):

Reason for Change in Field Procedure or Analytical Variation:

Variation from Field or Analytical Procedure (reference specific QAPP sections):

Special Equipment, Materials, or Personnel Required:

CONTACT	APPROVAL SIGNATURE	DATE
E & E Initiator/Project Manager: First and Last Name		
E & E Team Leader: First and Last Name		
EPA Project Manager: First and Last Name, Title		
EPA QA Manager: First and Last Name		

D Standard Operating Procedures

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

FIELD ACTIVITY LOGBOOKS

SOP NUMBER: DOC 2.1

REVISION DATE: 6/30/2017 **SCHEDULED REVIEW DATE: 6/30/2022**

Contents

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ecology and environment, inc.

STANDARD OPERATING PROCEDURE

GROUNDWATER WELL SAMPLING

SOP NUMBER: ENV 3.7

REVISION DATE: 9/30/2018 **SCHEDULED REVIEW DATE: 9/30/2023**

Contents

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for collecting representative water samples from groundwater wells, the most common example being a groundwater monitoring well. Every effort is typically made to ensure that each sample is representative of the water zone of interest, such as the saturated zone. This SOP also addresses some procedures that can be used to purge and sample plumbed groundwater wells such as domestic drinking water, public drinking water supply, and irrigation wells that contain a downhole well pump. Analysis of groundwater samples may be used to determine pollutant concentrations and their potential risk to public health, welfare, or the environment; extent of contaminants; or compliance with remedial standards.

This SOP addresses routine sample collection activities consisting of well purging; field measurement of water quality parameters; and collection of samples for off-site laboratory analysis of chemical, biological, radiological, or physical parameters. Specific sampling procedures may vary depending on the data quality objectives (DQOs) and regulatory requirements identified in project planning documents.

This groundwater well sampling SOP is intended for use by personnel who have knowledge, training and experience in the field sampling activities being conducted.

Other E & E SOPs that would typically also apply to groundwater well sampling include the following:

- DOC 2.1, Field Activity Logbooks;
- ENV 3.15, Sampling and Field Equipment Decontamination;
- ENV 3.16, Environmental Sample Handling, Packing, and Shipping;
- ENV 3.26, Handling Investigation-Derived Wastes; and
- GEO 4.15, Measuring Water Level and Well Depth.

2 Definitions and Acronyms

C	Celsius
DQO	Data quality objective
DO	Dissolved oxygen
E & E	Ecology and Environment, Inc.
EPA	(United States) Environmental Protection Agency
HDPE	High-density polyethylene
LDPE	Low-density polyethylene
µm	micrometer
mg/L	milligrams per liter
mL/min	milliliters per minute
mV	millivolt
NTU	Nephelometric turbidity unit

ORP	Oxidation-reduction potential
%	percent
PCB	Polychlorinated biphenyl
PFAS	Per- or polyfluoroalkyl substance
PFC	Perfluorinated compound
PTFE	Polytetrafluoroethylene (or Teflon™)
PVC	Polyvinyl chloride
QA	Quality assurance
QC	Quality control
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
SVOC	Semivolatile organic compound
VOA	Volatile organic analysis
VOC	Volatile organic compound

3 Procedure Summary

This SOP addresses purging and sampling methods primarily for groundwater monitoring wells. It also includes some procedures applicable to purging and sampling of plumbed groundwater wells such as domestic drinking water, public drinking water supply, and irrigation wells that contain a downhole well pump.

A primary goal of groundwater sampling is to provide data that are representative of actual aquifer conditions. Because standing water in a well casing may not be representative of aquifer conditions, that standing water and other near-well groundwater is typically purged (evacuated) from the well prior to sampling. The water level in the well is measured prior to, and frequently during, purging and sampling to determine the amount of standing water, location of the water with respect to the well screen, and drawdown and recovery rates. Water quality parameters such as pH, temperature, specific conductance, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity are typically monitored throughout purging to help determine when standing, stagnant water has been removed from the well and fresher aquifer water is available for sampling.

Groundwater wells are typically purged and sampled using a manual bailer or pumps such as a submersible pump, bladder pump, or peristaltic pump. In some cases, low-flow purging and sampling procedures will be specified when it is necessary to collect samples under conditions that are most reflective of ambient flow conditions and with as little hydraulic stress as possible at the well-aquifer interface. If dedicated or disposable equipment is not used, purging and sampling equipment will be decontaminated before use at a groundwater well location.

4 Cautions

4.1 Sampling

Cautions related to health and safety are discussed in Section 8.

Standard measures, such as the use of disposable gloves, should be used to avoid cross-contamination of samples between sample locations.

4.2 Special Considerations for Sampling for PFASs

When collecting samples for analysis of per- and polyfluoroalkyl substances (PFASs), it should be noted that common consumer products and commonly used environmental sampling equipment contain PFASs or PFAS derivatives that have the potential to cross-contaminate the samples, resulting in potential false positives for the PFAS analytes. Table 4-1 lists some common items and materials used during field efforts and sample collection that could contain PFASs, and acceptable non-PFAS substitutes to use. (Note: "PFAS" is the currently recognized term by the United States Environmental Protection Agency [EPA], the Centers for Disease Control and Prevention, and others for the class of chemical compounds addressed herein. PFASs might also be referred to as perfluorinated compounds [PFCs], although PFCs are a subset of PFASs.)

Table 4-1 Item and Material Guidance for Sampling for PFASs

Item/Material Type	Items/Materials to Avoid	Allowable Items/Materials
Pumps, tubing, connectors, and samplers	PTFE, Teflon™, and other fluoropolymer-containing materials[1] (including thread seal tapes and pastes); LDPE HydraSleeves	Peristaltic pump or stainless steel submersible pump HDPE or silicone tubing (LDPE[2] as a last resort) HDPE HydraSleeves Acetate items
Decontamination agents	Decon 90® (contains fluoro-surfactants); water from unknown sources	Alconox® or Liquinox® soap; PFAS-free water
Sample containers and packaging supplies	LDPE[2] or glass[3] bottles; PTFE-lined or Teflon™-lined caps; chemical ice packs (Blue Ice®), aluminum foil	Laboratory-provided, HDPE, or polypropylene[4] sample bottles; unlined HDPE or polypropylene[4] screw caps; regular ice made from PFAS-free water and contained in plastic (polyethylene) bags; standard Coleman® coolers are HDPE
Field documentation	Waterproof/treated paper or field books; plastic clipboards; Sharpies®; markers; adhesive paper products (such as Post-it® notes)	Plain paper; Masonite or metal clipboard; pens
Clothing, boots	Clothing or boots made of or with Gore-Tex™ or other synthetic water-resistant, waterproof, or stain-resistant materials; fabric softener-treated clothing; new clothing; Tyvek® material	Synthetic or cotton material; previously laundered clothing (preferably previously washed greater than six times) without the use of fabric softeners; polyurethane or PVC safety boots; powderless nitrile gloves; polyurethane or wax-coated rain gear
Personal care products	Cosmetics; moisturizers; hand cream; dental floss; most sunscreens; most insect repellants; and other related products	Avoid most personal care products the day of sampling; use PFAS-free or natural sunscreens and insect repellents (DEET is OK)

Table 4-1 Item and Material Guidance for Sampling for PFASs

Item/Material Type	Items/Materials to Avoid	Allowable Items/Materials
Food	Pre-packaged food; fast food wrappers and containers; candy wrappers; aluminum foil	Home-prepared foods (consumed only in a designated rest area); bottled water or hydration drinks

1 In cases where Teflon™-containing materials are unavoidable, ensure that adequate purging is performed prior to sampling (e.g., in-well pumps) and that rinsate blanks are collected prior to sampling.
2 Although LDPE is allowed by some agencies during sample collection, it is not recommended that samples be stored in LDPE sample containers.
3 Glass is to be avoided due to potential analyte loss from PFAS adsorption on the glass, not due to potential cross-contamination from glass.
4 Some laboratories recommend HDPE only and do not support the use of polypropylene bottles. Polypropylene bottles are allowed by EPA Method 537, for instance, because the method contains steps to recover PFASs that might have adsorbed to the inside of the container. Not all analytical methods, however, contain such steps.

Key:

DEET = N,N-Diethyl-m-toluamide
HDPE = High-density polyethylene
LDPE = Low-density polyethylene
PFAS = Polyfluoroalkyl substance
PTFE = Polytetrafluoroethylene (Teflon™)
PVC = Polyvinyl chloride

In addition to following the item/material guidance in Table 4-1, the following guidance should be followed to the extent practicable when sampling for PFASs:

- Wash hands before the sampling effort, even though gloves will be worn, to prevent the inadvertent transfer of PFASs to sampling supplies;
- Collect the samples for PFAS analysis prior to collecting samples for other parameters;
- Filter water samples with non-glass and non-PFAS-containing filters (glass fibers can potentially adsorb PFASs);
- Keep sampling supplies for PFAS sampling separate from other sampling supplies;
- Keep samples collected for PFAS analysis separate from other samples; and
- Include field blanks (such as trip blanks and/or equipment blanks) in the sampling protocol to check for potential cross-contamination from PFASs from non-field sources during sample transport and handling, as well as from equipment used during sampling.

5 Equipment and Supplies

The following is a general list of equipment and supplies. A detailed list of equipment and supplies will be prepared based on the project planning documents. In general, the use of dedicated or disposable equipment is preferred, to reduce the potential for cross-contamination between sampling locations, but equipment may be reused after thorough decontamination between sample locations.

- Water level indicator (e.g., electric sounder, steel tape, transducer, reflection sounder, airline, etc.) capable of measuring to 0.01-foot accuracy.

- Oil/water interface indicator.
- Keys or combinations for well cap locks.
- Organic vapor analyzer (e.g., photoionization detector).
- Specific purging/sampling equipment as applicable:
  - Bailers:
    - Reusable or disposable bailers of appropriate size and construction material.
    - Nylon or polypropylene line, enough to dedicate to each well.
    - Aluminum foil (to wrap clean bailers if not using disposable bailers).
  - Submersible Pump:
    - Submersible pump, preferably constructed of stainless steel or Teflon™.
    - Flow controller as applicable.
    - Safety cable (e.g., nylon or polypropylene line).
    - Flow meter with gate valve.
  - Bladder Pump:
    - Non-gas-contact bladder pump, preferably constructed of stainless steel or Teflon™.
    - Flow controller as applicable.
    - Spare bladders, typically polyethylene or Teflon™.
    - Compressor or compressed gas.
  - Suction Pump (Peristaltic Pump):
    - Suction pump.
    - Silastic (silicone) tubing of appropriate size and length for use in pump.
    - Flow meter with gate valve.
  - Low-Flow Purging/Sampling:
    - Pump (see above for options).
    - Transparent flow-through cell.
- Water discharge tubing for use with pumps, enough to dedicate to each well, and connectors (hose barbs, connectors, nipples, ferrules, etc.).
- Multi-parameter water quality measurement instrument suitable for measuring pH, temperature, specific conductance, ORP, and DO. If low-flow procedures and a flow-through cell are used, the water quality probes and flow-through cell may come together as a set.
- Turbidity meter.
- Water quality measurement calibration standards.
- Power for pumps: generator, gasoline, battery, and power cables.
- Chargers for any battery-operated equipment.
- Timepiece (preferably with a stopwatch function).
- Calculator.
- 5-gallon buckets (graduated), for purge water.

- Tools (pipe wrenches, wire strippers, electrical tape, tubing connectors, Teflon™ tape, box cutters, scissors, sharp knife, etc.).
- Associated equipment and supplies (e.g., meter stick or tape measure, aluminum foil, plastic sheeting, disposable gloves, sample containers, sample preservatives, field logbook, sampling log or field data sheets, sample custody and documentation supplies, decontamination supplies, sample packing/shipping supplies, safety supplies, and waste handling supplies).

6 Procedure

6.1 General Purging and Sampling Considerations

Groundwater sampling methods and equipment will be specified in project planning documents and will have been selected based on factors such as:

- Analytes of interest;
- Analytical volumes needed;
- The need for portable vs. dedicated equipment;
- Characteristics of the well being sampled, such as type, diameter, and depth to water;
- The need and availability of a power source for a sampling pump;
- Ease of decontamination;
- Project-specific regulations and requirements; and
- Cost.

In general, purging and sampling equipment must be constructed of materials that cannot interfere with the parameters being analyzed for. For example, some sample collection devices have parts constructed of plastic or rubber that cannot be used for sampling for volatile organic compounds (VOCs) and extractable organic parameters. Samplers constructed of glass, stainless steel, polyvinyl chloride (PVC), polytetrafluoroethylene (PTFE), or Teflon™ typically should be used, depending on the types of analyses to be performed (e.g., samples to be analyzed for metals should not be collected in metallic containers). Submersible and bladder pumps, which are inserted into the well, ideally should be constructed of stainless steel or Teflon™, and pumps ideally should have an adjustable and variable flow rate.

The water discharge tubing used with pumps should preferably be Teflon™ or Teflon™-lined polyethylene tubing when sampling is to include VOCs, semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and certain inorganics. If tubing constructed of other materials is used, adequate information must be provided to show that the materials do not leach contaminants or cause interference to the analytical procedures to be used. PVC, polypropylene, or polyethylene tubing typically is acceptable when collecting samples for metal and other inorganics analyses.

The use of pumps, tubing, and equipment dedicated to an individual well is ideal when possible. Non-dedicated and non-disposable purging and sampling equipment requires decontamination prior to each sample location. When non-dedicated or non-disposable groundwater purging and sampling equipment is used, purging and sampling should be conducted moving from least contaminated well to most contaminated well. As well, decontamination of non-dedicated and non-disposable equipment will be minimized if purging and sampling are completed for an individual well before moving to the next well.

Power sources such as gas-powered generators must be positioned downwind of the well during purging and sampling to prevent contamination of the well or sampled groundwater with chemical constituents in gasoline. Gas-powered equipment and containers of spare fuel should not be stored near supplies used to purge and sample wells.

Plastic sheeting is typically placed on the ground around the well to provide a clean place to stage and use purging and sampling equipment.

In addition to using a field logbook, groundwater purging and sampling are often documented on standardized forms such as a sampling log or field data sheets, which may be project-specific. Standardized forms are also available in many state and federal guidance documents.

6.2 Well Observations and Sampling Preparation

6.2.1 Water Quality Meter Calibration

1. Calibrate the multi-parameter water quality meter and turbidity meter on a daily basis, before use, in accordance with manufacturers' instructions and project planning documents. If the calibration results are out of range, repeat the calibration so that acceptable results are obtained or remove the instrument from service and obtain a replacement.
2. In some cases, an additional mid-day calibration is advised, especially if readings are observed to drift during the day or otherwise be unreliable or suspect.

6.2.2 Monitoring Wells

1. Start at the least-contaminated well.
2. Note the location of the well, date, and time in the field logbook or sampling log.
3. Remove the locking well cap.
4. Remove the well cap covering the well riser. Listen for indications of pressure or vacuum when opening the well riser cap.
5. If required, test the headspace in the well interior casing for the presence of organic vapors using an organic vapor analyzer or equivalent.
6. Measure water level (depth to water) and total depth of the well using appropriate reference points and procedural steps in E & E SOP GEO 4.15, Measuring Water Level and Well Depth. If possible, measure water levels in neighboring wells before any individual well is disturbed by purging and sampling, which could affect certain neighboring wells.
7. If free-phase product is expected in the well, measure depth to product and depth to water with an oil/water interface meter.
8. Measure the diameter of the well and calculate the volume of water in the well as follows:

$$V = \pi r^2 h$$

Where:

V	=	Static well volume
π	=	Mathematical constant, 3.14159
r	=	Inside radius of well casing
h	=	Height of water in well (depth of well – depth to water)

Ensure that the units of all measures are the same (e.g., feet). Other volume measurements may be derived from cubic feet using the following conversions:

1 cubic foot = 7.48052 gallons,
28.3168 liters,
0.02832 cubic meter, and
1,728 cubic inches.

A commonly used alternative short-cut version of the same equation is:

$$V = Tr^2(0.163)$$

Where:

V	=	Static well volume, in gallons
T	=	Height of water in well, in feet (depth of well – depth to water)
r	=	Inside radius of well casing, in inches
0.163	=	Conversion constant for converting casing radius in inches to feet, and converting cubic feet to gallons

9. Determine the required volume of groundwater to be removed from the well, e.g., three well volumes or as indicated in the project planning documents.

6.2.3 Plumbed Well Systems

1. Visually assess the well system, from the well to the nearest tap.
2. Large-volume well systems (e.g., industrial and public supply wells) operate at high pressure and care must be taken when opening a large-diameter tap. Most large-volume well systems have a small-diameter tap near the well head to reduce pressure for sample collection.
3. Plan to purge/sample from as close to the well head as possible, before water treatment or softening systems, if present.
4. Avoid removing installed pumping systems to purge/sample the well directly because this may disturb the well, loosen rust, or cause other changes or damage.
5. Remove any filters, aerators, screens, washers, or hoses from the faucet prior to purging/sampling, with the permission of the well owner, and document any plumbing features that could affect the water sample.

6.3 Purging

6.3.1 Purging Considerations

Groundwater wells are typically purged prior to sampling to ensure that the sampled groundwater is representative of actual aquifer conditions. The amount of purging performed on a well prior to sample collection depends on the intent of the monitoring program, constituents to be analyzed, hydrogeologic conditions, and produced water management requirements. Programs in which overall quality determinations of water resources are involved may require long purging periods to obtain a sample that is representative of the groundwater.

Traditionally, three to five well casing volumes of water are removed. For sites with deep wells or many wells, this can generate a large volume of groundwater that will require proper handling and disposal if potentially contaminated. In addition, the amount of time to purge multiple casing volumes can be significant for sites with deep wells or many wells.

Monitoring for defining a contaminant plume requires a representative sample of a small volume of the aquifer. These circumstances require that the well be pumped enough to remove the stagnant water, but not enough to induce flow from other areas.

Non-representative samples can result from excessive pumping of a well. For example, excessive pumping can cause stratification of certain contaminants in the groundwater formation, or dilute or increase contaminant concentrations from what is normal.

Water quality parameters are typically measured and recorded at regular intervals during purging. The data may be used to compute water table or aquifer transmissivity and other hydraulic characteristics, as well as determine or confirm when water quality has stabilized and purging can be considered to be complete. In some cases, wells may simply be purged of a specified number of well volumes without confirmation of water quality stability.

Low-flow purging focuses on pumping a well from the well screen at a flow rate below the recharge capacity of the formation. The specific rate of pumping is generally aquifer-dependent and typically less than 500 milliliters per minute (ml/min). By purging at low-flow rates, only the groundwater that enters through the well screen is theoretically purged from the well. Because stagnant water located above the pump intake in the well casing is not drawn into the pump, the full casing volume (or multiple casing volumes) would not have to be purged from the well prior to sampling. The low-flow purging approach can reduce the volume of water generated during purging and the time spent performing the task.

6.3.2 Water Quality Measurements

Water quality parameters are measured during purging to determine when water quality has stabilized and the water available for sampling is from the formation. The parameters are generally considered to have stabilized, and purging is considered to be complete, when at least three successive measurements are within specified guideline values. Some common stability criteria are:

- **pH**: +/- 0.1 standard unit;
- **Temperature**: +/- 3 percent (%);
- **Specific Conductance**: +/- 3%;
- **Oxidation-Reduction Potential (ORP)**: +/-10 millivolts (mV);
- **Dissolved Oxygen (DO)**: +/- 10% for values greater than 0.5 milligrams per liter (mg/L); if three successive DO measurements are less than 0.5 mg/L, consider the parameter stabilized; and
- **Turbidity**: +/- 10% for values greater than 5 nephelometric turbidity units (NTUs); if three successive turbidity measurements are less than 5 NTU, consider the parameter stabilized.

In many cases, if all parameters other than turbidity have stabilized and turbidity is ≤50 NTUs, purging is considered complete and groundwater samples may be collected. If all parameters other than turbidity have stabilized and turbidity does not expeditiously reduce to ≤50 NTUs, purging is typically considered to be complete, and separate filtered and unfiltered samples may be required for metals and other analyses.

Water quality will be measured and recorded at pre-determined intervals specified in project planning documents. A typical interval is one-quarter of a well volume.

Project-specific requirements for water quality stability may be different from the above and will be followed.

6.3.3 Purging Wells Using Various Equipment

Each of the procedures below assumes that purging will be conducted until stable and acceptable water quality parameter values are achieved; information such as water level, pumping rate, drawdown rate, and water quality measurements is recorded in the field logbook or sampling log; and the proper purge volume is removed in accordance with project planning documents. These steps are not repeated below.

6.3.3.1 Bailer

1. Attach the bailer line to the bailer and lower the bailer slowly (trying not to agitate the water) until it is completely submerged.
2. Pull the bailer out of the well, ensuring that the line falls onto the plastic sheeting.
3. Empty the bailer into a graduated 5-gallon bucket.
4. Repeat until the required purge volume has been removed.
5. When the 5-gallon bucket is full, empty it into a 55-gallon drum or otherwise discharge the contents of the bucket as specified in project planning documents.

6.3.3.2 Submersible Pump

1. Assemble the pump, water discharge tubing, power source, and safety cable.
2. Lower the pump and assembly into the well to a point at least a few feet below the water level and above the bottom of the well. The midpoint is often used. Measure the new initial water level.
3. Begin purging at a low pumping rate, and increase the rate until water discharge occurs. Using a flow meter or a bucket and a stopwatch, determine the flow rate and calculate the time required to remove the required volume of water from the well.
4. Collect the purge water in graduated 5-gallon buckets, in 55-gallon drums, or as indicated in the project planning documents.
5. Lower the pump by stages until it is just above the screen, and continue to purge until the required volume of water has been removed from the well. Measure the water level as necessary to monitor drawdown rate and well recovery. In cases where the well will not yield water at a sufficient recharge rate, pump the well dry and allow it to recover.

6.3.3.3 Bladder Pump

1. Assemble the pump, water discharge tubing, compressor/control box, and power source.

2. Adjust the flow rate as needed to allow smooth intake and discharge cycles.
3. Lower the pump and assembly into the well to a point at least a few feet below the water level and above the bottom of the well. The midpoint is often used. Measure the new initial water level.
4. Refer to the remaining procedural steps for a submersible pump (see above).

6.3.3.4 Suction Pump (Peristaltic Pump)

1. Assemble the pump, tubing, and power source.
2. Lower the sample tubing into the well to a point at least a few feet below the water level and above the bottom of the well. The midpoint is often used. The pump stays outside of the well.
3. Refer to the remaining procedural steps for a submersible pump (see above).

6.3.3.5 Low-Flow Purging

The objectives of low-flow purging and sampling are to collect samples under conditions that are representative of ambient flow conditions in the subsurface and with as little hydraulic stress as possible at the well-aquifer interface. Some key steps related to low-flow purging are included below. Refer to EPA SOP EQASOP-GW 001, Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells, for the complete procedure.

1. Assemble the pump, tubing, flow-through cell, and power source. Wells with low recharge rates may require the use of pumps that can attain low pumping rates, such as bladder or peristaltic pumps. Be advised that EPA and other agencies may not favor the use of a peristaltic pump when collecting sample that will be analyzed for pH and volatile constituents, because use of a peristaltic pump may cause pH modifications or degassing of the sample.
2. Lower the pump and assembly into the well to a suitable pump intake depth (often based on the location of the well screen), which also ideally should be at least a few feet above the bottom of the well. Measure the new initial water level.
3. Begin purging at a low pumping rate, and increase the rate until water discharge occurs. Collect the purge water into graduated 5-gallon buckets. An initial flow rate of a maximum of 100 to 500 mL/min is typical. Adjust the flow rate until there is little or no water level drawdown. Measure water level as necessary to monitor drawdown rate and well recovery. If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging. Purge volume calculations should use the stabilized drawdown value, not initial drawdown.
4. If the initial water level is above the top of the well screen, do not allow the water level to drop below the top of the well screen.
5. Measure water quality parameters using the flow-through cell at key points during purging, such as at the beginning of purging, after the water level has stabilized, and periodically during purging until water quality stability is observed. Measure turbidity with a separate instrument that is either connected to the water discharge tubing through a connection separate from the flow-through cell or by using a standalone turbidity meter. Measure the parameters at a frequency approximately equal to the rate at which water in the flow-through cell is fully exchanged.

6.3.4 Purging Plumbed Wells

1. Small-volume well systems (e.g., domestic and livestock wells) typically have a 25-to-100-gallon pressure tank connected directly to the well. Consider clearing the volume of the pressure tank to purge the well.
2. Plan to purge from as close to the well head as possible, before water treatment systems, if present.
3. Wells that have been producing sufficiently to clear three to five times the well volume within the last 24 hours may not require extensive purging prior to sampling. Because this may not be known, and the casing volume also may not be known, plumbed wells are typically "purged" by opening the faucet or spigot nearest the well for approximately 10 to 15 minutes prior to sampling to allow for a fresh water sample to be collected.
4. Measure the purging flow rate by the time it takes to fill a container with a known volume (e.g., a graduated 5-gallon bucket).
5. Measure water quality parameters per the project planning documents. Purging is considered complete when the water quality parameters have stabilized.
6. Collect the purge water in the graduated bucket. Discharge the contents of the bucket as specified in project planning documents.
7. Record information such as flow rate, water quality measurements, and purge volume in the field logbook or sampling log.

6.4 Sampling

6.4.1 Sampling Considerations

Some steps in common to groundwater sampling regardless of the equipment used are as follows:

- Ensure that the well has adequately recharged after purging.
- Collect samples for VOCs, sulfide, and similar analyses as soon as possible in the sampling sequence and in a way that minimizes disturbance of the water, in order to minimize VOC loss. Sample retrieval systems generally viewed as suitable for the valid collection of samples for VOC analysis include bailers, submersible pumps, and bladder pumps. When collecting samples for the analysis of VOCs, do the following:
  - If the samples are required to be preserved, use pre-preserved volatile organic analysis (VOA) vials.
  - Open the VOA vial and set the cap in a clean place.
  - If using a bailer, deploy and retrieve the bailer as gently as possible. If using a pump, reduce the pumping rate as much as possible, e.g., to approximately 100 mL/min.
  - Fill the vial to the top until a convex meniscus forms on the top of the water. Do not overfill the vial.
  - Place the cap directly over the top of the vial and screw down firmly. Do not overtighten and break the cap.

  - Invert the vial and tap gently. If an air bubble appears, discard the sample and re-collect it. The sample must not contain trapped air.
  - Place collected samples on their sides in a cooler chilled to 4±2°C pending sample management and transport to the analytical laboratory.

- Filter samples as required by the project planning documents. Filtering is commonly performed when testing for metals in the groundwater, in which case both an unfiltered and filtered sample are collected to analyze total metals and dissolved metals, respectively. When pumps are used to sample, filtration is often performed at the time of sampling using a 0.45-micrometer (µm) (same as micron) cartridge filter installed in-line with the sampling system. The filter is attached to the end of the water discharge tubing prior to discharge into the sample containers. When using an in-line filter, the pumping rate should be reduced somewhat to accommodate the resistance of the filter, thereby preventing damage to the filter or to pump parts such as bladders. If not filtered in-line, samples are filtered following collection, using a 0.45-µm barrel filter or vacuum filter and a powered vacuum pump, hand pump, or similar. The sample is poured from the sample container into the chamber atop the filter, vacuum-pumped through the filter, and directed back to the sample bottle.
- Use pre-preserved sample containers or preserve samples as soon as possible after sample collection and filtration. Pre-preserved sample containers typically cannot be used for samples that are not filtered in-line during sample collection. Verify and document proper preservation in the field by pouring a small amount of the sample into the container lid or other clean container and measuring pH using a test strip (the test strip should not be inserted directly into the sample container).
- Place samples requiring cooling to 4±2°C on ice immediately following collection.
- Collect applicable quality control samples as outlined in project planning documents (also see Section 7).
- Record sampling information in the field logbook or sampling log.
- Complete a chain-of-custody form and handle and pack samples in accordance with project planning documents and E & E SOP ENV 3.16, Sample Handling, Packing, and Shipping.
- Non-dedicated and non-disposable sampling equipment requires decontamination prior to each sample location.

6.4.2 Sampling Wells Using Various Equipment

Each of the procedures below assumes that the well was recently purged and the necessary equipment is already at the well location (see Section 6.3.3). As well, the steps in Section 6.4.1 that are common to all procedures are not repeated below.

6.4.2.1 Bailer

1. Attach a bailer line to the bailer. If a bailer was used for purging, the same bailer and line may be used for sampling.
2. Lower the bailer slowly and gently into the well, taking care not to shake the well casing or splash the bailer into the water. Lower the bailer to different points adjacent to the well screen to ensure that a representative water sample is collected.

3. Slowly and gently retrieve the bailer from the well, minimizing contact with the well riser.
4. Carefully pour the water into individual sample containers or insert a stopcock valve into the bottom of the bailer to more cleanly direct the water into the sample containers.
5. After collecting all samples from the well, either dispose of, decontaminate, or dedicate the bailer to that well to ensure no cross-contamination between wells or samples.

6.4.2.2 Submersible Pump

1. Ensure that the pump and assembly are positioned in the well at a point at least a few feet below the water level and above the bottom of the well. A point just above the screened interval is often used.
2. Attach a gate valve to the discharge line, and adjust the flow rate to the minimum that will allow groundwater to come to the surface. If no gate valve is available, discharge the sample into a clean glass jar and fill the sample containers from the jar. Increase the flow rate as long as rapid well drawdown is not occurring and volatile constituents are not being collected. Measure water level as necessary to monitor drawdown rate and well recovery.
3. After collecting all samples from the well, remove the pump and assembly and properly decontaminate it prior to use in the next well. Do not reuse the tubing in another well. If dedicated to a particular well, tubing may be left in place for future sampling events.

6.4.2.3 Bladder Pump

1. Ensure that the pump and assembly are positioned in the well at a point at least a few feet below the water level and above the bottom of the well. A point just above the screened interval is often used.
2. Increase the cycle time and reduce the pressure to the minimum that will allow groundwater to come to the surface. Increase the flow rate as long as rapid well drawdown is not occurring and volatile constituents are not being collected. Measure water level as necessary to monitor drawdown rate and well recovery.
3. After collecting all samples from the well, remove the pump and tubing from the well and properly decontaminate the pump prior to use in the next well. Do not reuse the tubing and bladder in another well. If dedicated to a particular well, the bladder and tubing may be retained for future sampling events.

6.4.2.4 Suction Pump (Peristaltic Pump)

1. Ensure that the tubing is positioned in the well at a point at least a few feet below the water level and above the bottom of the well. A point just above the screened interval is often used.
2. Attach a gate valve to the discharge line if the suction pump discharge rate cannot be controlled. If no gate valve is available, discharge the sample into a clean glass jar and fill the sample containers from the jar. Increase the flow rate as long as rapid well drawdown is not occurring and volatile constituents are not being collected. Measure water level as necessary to monitor drawdown rate and well recovery.
3. After collecting all samples from the well, remove the tubing from the well. Do not reuse the tubing in another well. If dedicated to a particular well, tubing may be left in place for future sampling events.

6.4.2.5 Low-Flow Sampling

Some key steps related to low-flow sampling are included below. Refer to EPA SOP EQASOP-GW 001, Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells, for the complete procedure.

1. Ensure that the pump and assembly are positioned in the well at a suitable pump intake depth (often based on the location of the well screen), which also should ideally be at least a few feet above the bottom of the well.
2. Disconnect the water discharge tubing from the flow-through cell. Discharge sample directly into the sample containers without passing the water through the flow-through cell. Adjust the flow rate to the minimum that will allow groundwater to come to the surface. Increase the flow rate with discretion as long as rapid well drawdown is not occurring and volatile constituents are not being collected. Measure water level as necessary to monitor drawdown rate and well recovery. One of the objectives of low-flow sampling is collect samples under conditions that are representative of ambient flow conditions in the subsurface. Do not allow the water level to drop below the top of the well screen.
3. After collecting all samples from the well, remove the pump and assembly from the well and properly decontaminate the pump prior to use in the next well. Do not reuse the tubing in another well. If dedicated to a particular well, tubing may be left in place for future sampling events.

6.4.3 Sampling Plumbed Wells

1. Following purging, remove any diversion hoses and similar items from the sampling port or tap and run the water briefly to clear any immediate contaminants.
2. Adjust the flow rate to a smooth flowing water stream, without splashing, for sample collection. This will minimize spikes or dips in flow pressure when sampling, which may dislodge material in the system. This step is especially important during sample collection for VOC analysis.
3. Attempt to collect water before it is directed through an in-line filter, water heater, water softener, or other treatment system. If determining how well the filter or treatment system is working is an additional goal of the project, collect additional samples after these systems.
4. Collect the water into individual sample containers.
5. After collecting all samples from the well, either dispose of or decontaminate sampling supplies, before reuse at another location, to ensure no cross-contamination between samples.

7 Quality Assurance/Quality Control

The program/project manager should identify personnel for the field team who have knowledge, training and experience in the groundwater sampling to be conducted. One member of the field team should be designated as the lead for groundwater sampling and will be responsible, with support from other field personnel, for implementing the procedures in this SOP. The program/project manager should also identify additional personnel, if necessary, to complete associated procedures (e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal).

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan [SHASP]) will be reviewed by field personnel to understand the sampling procedures that have been specified to result in groundwater samples that will meet project DQOs. Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs, including the sampling protocol for QC samples such as trip blanks, equipment rinsate blanks (to assess the effectiveness of field decontamination methods for non-dedicated and non-disposable equipment, or to test non-inert field equipment for the potential to leach contaminants into the samples), field duplicates, and other types of field and analytical QC samples. Field duplicates are typically collected from at least one location and treated as separate samples, blind to the laboratory. Certain field blanks should be processed at the site location to account for ambient and other site-specific conditions.

Collecting representative groundwater samples is an important quality consideration. Techniques to maximize the collection of samples that are representative of the aquifer or formation of interest are included in the procedures in Section 6 and include first purging the well of the required volume of standing, stagnant water; measuring water quality during purging to monitor stability; and the use of low-flow purging/sampling procedures if prescribed.

8 Health and Safety

Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the Corporate Health and Safety Program.

Unique hazards associated with collecting samples from groundwater wells can include:

- The use of gas-powered generators or electrical sources to provide power for sampling pumps: Gas-powered equipment will be fueled only when it is off and cool to the touch. Batteries, generators, and other sources of electrical power will be handled safely in accordance with the SHASP.

- The potential for contacting groundwater contaminated with site contaminants such as chemical, radioactive, and/or pathogenic biological material: The SHASP will provide instruction for safe handling of contaminated site materials.

- The use of sample preservatives either in pre-preserved sample containers or as added by the field team during sample management: The field team will wear the personal protective equipment specified by the SHASP, handle samples with care, and collect and process such samples in a well-ventilated area.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

10 References

American Society for Testing and Material (ASTM). 2013. Standard Guide for Sampling Ground-Water Monitoring Wells. D4448-01. ASTM International. West Conshohocken, Pennsylvania.

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United States Geological Survey (USGS). 2015. *National Field Manual for the Collection of Water-Quality Data*. Chapter A4, Collection of Water Samples. Version 2.0. Chapter revised September 2006.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

SURFACE and SHALLOW SUBSURFACE SOIL SAMPLING

SOP NUMBER: ENV 3.13

REVISION DATE: 5/25/2012 **SCHEDULED REVIEW DATE: 5/26/2017**

Contents

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures utilized by E & E for collecting surface and shallow subsurface environmental soil samples. The purpose of soil sampling may range from simple reconnaissance to complex sampling programs. This SOP can be followed for all routine sample collection activities which may include: visual or other observations, in situ or ex situ field measurements (monitoring), or sample collection for biological, chemical, geological, radiological or physical analysis. Site-specific sampling procedures vary depending on the data quality objectives (DQOs) identified in program/project planning documents.

E & E routinely utilizes three types of surface and shallow subsurface environmental soil collection procedures, hand scoop, hand coring, and hand auger. Powered hand augers are sometimes used and the procedure is addressed in this SOP. The definition of the depth of a "surface" soil sample is dependent on the program/project specific DQOs); and may be driven by regulatory, risk-based or other considerations. Hand sampling is generally limited to no more than three feet (one meter) below ground surface. The site-specific depth interval of soil collection is identified in the project planning documents.

Procedures for collecting soil samples for volatile organic compound (VOC) analyses are presented in the E & E VOC Soil and Sediment Sampling SOP ENV 25.

Procedures for collecting "deeper" subsurface soil samples (using back hoes, drill rigs and direct push equipment) are presented in the E & E Borehole Installation Methods SOP GEO 4.7.

Procedures for sample handling are defined in E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16. Site-specific sample handling procedures are dependent on the project DQOs.

Procedures for equipment decontamination are defined in E & E Sampling Equipment Decontamination SOP ENV 3.15. Site-specific equipment decontamination procedures are dependent on the project DQOs.

This surface and shallow subsurface soil sampling SOP is intended for use by personnel who have knowledge, training and experience in the field soil sampling activities being conducted.

2 Definitions and Acronyms

cm	centimeter
DQO	Data Quality Objective
E & E	Ecology and Environment, Inc.
SHASP	Site Specific Health and Safety Plan
SOP	Standard Operating Procedure
VOC	Volatile Organic Compound

3 Procedure Summary

Pre-cleaned spoons, trowels, or other types of scoops are used to collect shallow (usually less than 6 inches [15 cm] deep) soil samples using a hand scoop procedure. Shallow subsurface soil is collected manually using scoops from the sides of hand dug excavations. Pre-cleaned hand soil core samplers and/or bucket augers are used for collecting relatively undisturbed shallow (usually no deeper than 3 feet [1 meter]) subsurface soil samples. The corer barrel/bucket auger is advanced into the soil to the pre-determined depth identified in the project planning documents. In some cases, corers may include a liner on the interior of the core barrel. Soil cores may be sectioned to provide vertical profiles of soil characteristics.

Disturbed soil samples are collected directly from the auger when continuous flight (screw) augers are used

Unless otherwise specified, surface soil scoop aliquots are combined, homogenized and then placed in appropriate sample containers. Volatile organic and sulfide samples are collected immediately after sample retrieval, regardless of the sampling procedure used. VOC samples are not homogenized (see E & E VOC Soil and Sediment Sampling SOP ENV 25) If multiple samples are required to provide the sample volume identified in the project planning documents, then samples are thoroughly homogenized prior to collection of aliquots for testing.

4 Cautions

This SOP is applicable to routine E & E surface and shallow subsurface soil sampling and is limited to relatively shallow soil sampling depths Hand augers and corers used in this SOP are generally effective only to a maximum depth of 3 feet (1 meter) below the soil surface. The depth of sample collection will be limited if soil is sandy, clayey or rocky. Grass, roots, or other natural or anthropogenic materials may not be considered part to the soil sample.

Because the sampling devices specified within this SOP provide limited sample volumes, multiple samples may be required to collect sufficient volume for sample analysis. Samples from multiple locations also may be collected and composited to provide a sample representative of a larger area. Sample compositing and homogenization should be addressed in the project planning documents. If a compositing scheme is employed and an area(s) is not visually consistent with other areas, then observations should be noted in the field log and a course of action determined based on the program/project DQOs. Samples for volatile organics, sulfide, or similar analyses are normally collected as discrete aliquots and should be containerized as soon as possible after collection and prior to compositing and homogenization. Field personnel must maintain an awareness of the soil sample volume collected versus the volume required to meet program/project DQOs.

Maintaining sample integrity requires selecting a soil sampling device and procedure that meets project DQOs. Carefully following procedures minimizes the disruption of the soil structure and subsequent changes in physiochemical and biological characteristics.

Continuous flight augers are satisfactory for use when a composite of the soil column is desired.

If a powered auger is used, if possible, position the power unit downwind of the sample location to avoid fumes from fuel used to power the unit.

At sites with known or suspected contamination, based on the data available, samples are collected moving from least to most contaminated soil.

Re-use of equipment may be unavoidable given size and cost. Decontamination matched to DQOs is specified in the project planning documents.

Experience has shown that real-world conditions (e.g., variable soil conditions such as the presence of rocks or trash) may lead to unacceptable soil sample recoveries and multiple attempts to collect soil samples will be required at some locations.

Abandon auger and/or core holes according to applicable regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

Standard measures, such as the use of disposable gloves, that meet project DQOs, are used to avoid cross contamination of samples.

As with all intrusive sampling work, project planning should address the potential for encountering subsurface “utilities” and the measures to be taken to avoid problems in the field.

5 Equipment and Supplies

The equipment and supplies required for field work depend on the program/project DQOs. The following is a general list of equipment and supplies. A detailed list of equipment and supplies should be prepared based on the project planning documents. In general, the use of dedicated or disposal equipment is preferred but equipment may be re-used after thorough decontamination between sample locations (refer to E & E Sampling Equipment Decontamination SOP ENV 3.15).

- Stainless-steel or Teflon™ spoons, trowels, or scoops. Other construction material may be acceptable depending upon the program/project planning documents and DQOs
- Stainless-steel mixing bowls. Other bowl construction material may be acceptable depending upon the program/project planning documents and DQOs
- Hand-driven bucket/continuous flight auger(s), split core sampler(s), and single or multistage core sampler(s)
- Rubber mallet or T-bar to help drive hand augers
- Powered auger(s)
- Spade(s) and/or shovel(s)
- Liners and/or catchers for augers or core samplers as specified in the project planning documents
- Pipe cutter(s), stainless steel knives(s), or power saw to cut liners
- Survey stakes or flags to mark locations
- Ancillary equipment and supplies, e.g., meter stick or tape measure, aluminum foil, plastic sheeting, disposable gloves

Supporting equipment and supplies also may be required to address the following:

- Field logbooks and supplies (Refer to project planning documents and the E & E Field Activity Logbooks SOP DOC 2.1 for details)
- Decontamination equipment and supplies (Refer to project planning documents and E & E Sampling Equipment Decontamination SOP ENV 3.15for details)
- Sample containers, preservatives, and shipping equipment and supplies (Refer to project planning documents and the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for details)
- Waste handling supplies (Refer to project planning documents and E & E Handling Investigation-Derived Wastes SOP ENV 3.26 for details)

6 Procedures

E & E staff will use the following procedures for completing soil sampling:

- Review relevant project planning documents, e.g., work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, etc.
- Select the sampling procedure(s) that meet project DQOs.
- Refer to the E & E Field Activity Logbooks SOP DOC 2.1 for guidance on the types of information that should be recorded for each sample.
- Refer to the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for guidance on how samples should be labeled, packaged, and shipped.

6.1 Hand Scoop Surface and Subsurface Soil Sampling

- Surface and shallow subsurface soil samples may be collected by hand using scoops.
- Pre-cleaned spoons, trowels, or scoops are used to excavate shallow soil.
- Sample collection intervals are identified in the project planning documents.
- Clear the area to be sampled of surface debris (e.g., twigs, rocks, and litter).
- Carefully remove the top layer of soil to the desired sample depth with a precleaned tool.
- When sampling from the sides or bottom of an excavation, use a pre-cleaned, scoop, spoon, or trowel to remove and discard the thin layer of soil from the area that came into contact with the shovel or spade.
- Collect sufficient sample volume to meet the DQOs identified in the project planning documents
- Place aliquots to be analyzed for volatile organic analytes and/or sulfides directly into sample containers (i.e., prior to homogenization). Procedures for collecting soil samples for VOC analyses are presented in the (see E & E VOC Soil and Sediment Sampling SOP ENV 25).
- Empty hand-collected samples into a pre-cleaned stainless steel bowl (or other type as specified in the project planning documents).
- If multiple hand collected samples are necessary to collect adequate sample volume, they should all be combined in the bowl prior to homogenization.
- Homogenize the sample(s) as thoroughly as possible.
- Transfer sample aliquots to appropriate sample containers and preserve as required in the project planning documents.
- Return unused soil to the excavation, level the area, replace grass turf as necessary.

6.2 Subsurface Soil Sampling with a Soil Core Samplers

This system consists of pre-cleaned corer barrels (with liners and liner caps, as appropriate), caps, core tips, and slide hammer. The dimensions of the core barrel define the volume and depth interval of possible sample collection. Core sampling is recommended if accurate resolution of sample depths is a DQO. Hand coring will generally be limited to 2-inch diameter – 3 foot (1 meter) long samples.

There are a variety of manual soil core sampling devices available for collecting undisturbed soil core samples. Split core, single core, and multistage core samplers may be used with or without liners that are used to avoid contact between the soil and the corer.

The following procedures are used for collecting soil samples with the soil core sampler:

- Assemble the soil core sampler based on manufacturer instructions and project DQOs (e.g., using a liner and/or catcher).
- Clear the area to be sampled of surface debris (e.g., twigs, rocks, and litter).
- Using the slide hammer or sledge hammer or pounding sleeve, begin driving the pre-cleaned corer into the soil until the desired upper sampling depth is reached.
- Carefully retrieve the corer from the boring.
- Decontamination or replace the core barrel with a pre-cleaned core barrel and resume coring. See E & E Sampling Equipment Decontamination SOP ENV 3.15 for decontamination procedures.
- Soil cores should be extruded or split as soon as possible following collection.
  - Place core barrel or liner on clean surface
  - Carefully remove end caps and/or catchers
  - Evaluate compaction (core length versus depth of penetration)
  - For transverse sectioning, beginning at the soil surface, measure and mark the sample sections on the outside of the liner
    - Cut the liner with a manual pipe cutter or core liner and core with a decontaminated saw blade into marked sections.
    - Extrude the soil from the cut segments of the liner. If necessary use a plunger cover with aluminum foil to aid in extruding the core.
    - Empty the core segment into a stainless steel bowl (or other type as specified in the project planning documents).
    - Record observations of the soil types.
    - Immediately collect volatile organic analyte and sulfide samples.
  - For longitudinal sectioning, open the split tube or use a knife to cut the liner and expose the upper half of the soil cylinder.
    - Beginning at the soil surface, measure and mark the sample sections using a tape measure set aside the core.
    - Record observations of the soil types.
    - Immediately collect volatile organic analyte and sulfide samples.
    - Scope the core segment into a stainless steel bowl (or other type as specified in the project planning documents).
- If multiple core segments are necessary to collect adequate sample volume, they should all be combined in the bowl prior to homogenization
- Homogenize the sample as thoroughly as possible

- Transfer sample aliquots to appropriate sample containers and preserve as required in the project planning documents.
- Return unused soil to the boring, level the area, replace grass turf as necessary.

6.3 Subsurface Soil Sampling with Bucket Augers

This system consists of pre-cleaned bucket augers, a series of extensions, and a T-handle. The dimensions of the bucket define the volume and depth interval of possible sample collection. The following procedures are used for collecting soil samples with the bucket auger:

- Attach the bucket auger bit to a drill rod extension, and attach T-handle to the drill rod.
- Clear the area to be sampled of surface debris (e.g., twigs, rocks, and litter).
- Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole until the desired upper sampling depth is reached.
- Decontaminate the bucket auger or replace the bucket auger with a pre-cleaned auger bucket and resume augering. After reaching the desired depth (no more than the maximum length of the auger bucket), carefully remove the auger from the boring.
- Empty bucket auger-collected samples into a pre-cleaned stainless steel bowl (or other type as specified in the project planning documents) OR use pre-cleaned scoops and carefully subsample soil from within the bucket that has not come in contact with the auger.
- Immediately collect volatile organic analyte and sulfide samples.
- If multiple bucket auger collected samples are necessary to collect adequate sample volume, they should all be combined in the bowl prior to homogenization.
- Homogenize the sample(s) as thoroughly as possible.
- Transfer sample aliquots to appropriate sample containers and preserve as required in the project planning documents.
- If another sample is to be collected in the sample hole, but at a greater depth, decontaminate or re-attach a pre-cleaned auger bucket, and follow steps above.
- Return unused soil to the excavation, level the area, replace grass turf as necessary

6.4 Subsurface Soil Sampling with Continuous Flight Augers

This system consists of pre-cleaned continuous flight augers, a series of extensions, and a T-handle. The dimensions of the flight define the volume and depth interval of possible sample collection.

When continuous flight augers are used, the sample can be collected directly off the flights. Continuous flight augers are satisfactory for use when a composite of the soil column is desired.

A powered auger may be used at this time. The following procedures are used for collecting soil samples with an auger:

- Attach the continuous flight auger to a drill rod extension, and attach T-handle to the drill rod.
- Clear the area to be sampled of surface debris (e.g., twigs, rocks, and litter).

- Begin augering, periodically removing and depositing accumulated soils onto a plastic sheet spread near the hole until the desired upper sampling depth is reached.
- Decontaminate or replace the auger flight with a pre-cleaned auger flight and resume augering. After reaching the desired depth (no more than the maximum length of the auger flight), carefully remove the auger from the boring.
- Place auger-collected samples into a pre-cleaned stainless steel bowl (or other type as specified in the project planning documents) OR use pre-cleaned scoops and carefully subsample soil from within the auger flights as it comes to the surface.
- Immediately collect volatile organic analyte and sulfide samples.
- If multiple auger flight-collected samples are necessary to collect adequate sample volume, they should all be combined in the bowl prior to homogenization
- Homogenize the sample(s) as thoroughly as possible.
- Transfer sample aliquots to appropriate sample containers and preserve as required in the project planning documents.
- If another sample is to be collected in the sample hole, but at a greater depth, decontaminate or re-attach a pre-cleaned auger flight, and follow steps above.
- Return unused soil to the excavation, level the area, replace grass turf as necessary.

7 Quality Assurance/Quality Control

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, SHASP, *et al*) should be reviewed by field personnel to identify sampling procedure(s) that will most likely provide surface and shallow subsurface soil samples that meet project DQOs.

The program/project manager should identify personnel for the field team who have knowledge, training and experience in the field soil sampling activities being conducted. One member of the field team should be designated as the lead for soil sampling and will be responsible, with support from other field personnel, for implementing the procedures in this SOP. The program/project manager should also identify additional personnel, if necessary, to complete ancillary procedures, e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal.

The soil sampling lead should prepare a detailed equipment checklist before entering the field and verify that sufficient and appropriate equipment and supplies are taken into the field.

Quality assurance/quality control samples (e.g., co-located samples) are collected according to the site quality assurance project plan. Field duplicates are collected from one location and treated as separate samples. Field duplicates are typically collected after the samples have been homogenized. Collocated samples are generally collected from nearby locations and are collected as completely separate samples.

In cases where multiple hand-collected scoop, auger or core samples are required to generate an adequate sample volume, homogenization is important. Field personnel should collect sample aliquots only after mixing has produced soil with textural and color homogeneity.

At sites with known or suspected contamination, samples should be collected moving from least to most contaminated areas.

8 Health and Safety

Prior to entering the field, all field personnel formally acknowledge that they have read and understand the project specific health and safety plan.

Augers and soil core sampling apparatus are inherently dangerous pieces of heavy equipment which a high “pinch” potential. Care should be taken at all times when handling such equipment, not just during sample collection.

Prior to any subsurface work, verify that underground utilities have been located and marked.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be entered in this section and included with the project planning documents.

10 References

The following list sources of technical information on soil sampling.

Barth, D. S. and B. J. Mason, 1984, *Soil Sampling Quality Assurance User’s Guide*, EPA-600/4-84-043.

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END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

SAMPLING AND FIELD EQUIPMENT DECONTAMINATION

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Contents

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for decontaminating sampling and other field equipment to 1) minimize sample cross-contamination and 2) promote health and safety by preventing the transfer of site contaminants to other locations. This SOP is applicable to the decontamination of equipment that will be re-used in the field and equipment that will be returned to a rental vendor, subcontractor (e.g., drilling equipment), warehouse, or other facility prior to re-use.

Project-specific data quality objectives (DQOs) dictate the scope and goals of the field investigation, including the sampling design, which further dictate the types of sampling and other field equipment needed for a project. Project planning documents will identify the site-specific decontamination procedures. This SOP applies to equipment routinely used for:

- Water sampling (e.g., buckets, bailers, pump, and tubing);
- Flow/water depth measuring (e.g., velocity meters, stream gauges, and depth sounders);
- Soil and sediment sampling (e.g., corers, augers, trowels, shovels, scoops, direct-push samplers, homogenization buckets, and mixing tools);
- Field and sampling support (e.g., tapes/rulers/meter sticks, tools); and
- Ambient monitoring and sampling (e.g. dust monitors, vapor monitors, air samplers, radiation monitors).

Decontamination of reusable sampling equipment can be time-consuming and costly and may require additional sampling and analyses to verify the effectiveness of decontamination procedures (e.g., rinsate blanks) and/or determine the content of generated decontamination waters. The use of dedicated or clean disposable equipment (e.g., Teflon or plastic bailers for groundwater sampling, aluminum bowls for soil homogenization) is typically preferred, when practicable (assuming that the disposable equipment does not eventually have to be handled as a hazardous waste).

This SOP does not address decontamination of protective clothing or personnel, which will be addressed in the site-specific health and safety plan (SHASP) developed for the fieldwork. This SOP also does not address decontamination for biohazards, reactive or explosive materials, or prolonged exposure to a contaminant; or decontamination necessary to result in ultra-clean sampling equipment required for the investigation and analysis of very low levels of certain environmental contaminants.

This SOP is intended for use by personnel who have knowledge, training, and experience in the field activities being conducted and who understand the importance of decontamination in meeting project-specific DQOs.

2 Definitions and Acronyms

ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations
Deionized water	Purified water produced by filtration through deionizing columns or other similar means, which removes charged particles and mineral ions

Distilled water	Purified water produced by distillation, which removes minerals, salts, particulates, and certain other impurities
DQO	Data quality objective
E & E	Ecology and Environment, Inc.
EPA	(U.S.) Environmental Protection Agency
Potable water	Water from a treated municipal or industrial drinking water distribution system
QA	Quality assurance
QC	Quality control
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure

3 Procedure Summary

Equipment decontamination procedures vary depending on the DQOs identified in the project planning documents. These planning documents will identify the types and levels of contamination anticipated, specify appropriate decontamination procedures and supplies, and address the handling of investigation-derived waste.

A typical hazardous waste site will have a specific location for decontamination activities in an area designated as the contamination reduction zone.

Several different procedures are presented for the decontamination of equipment. In general, equipment that is in direct contact with collected samples will be washed with a detergent solution followed by a series of rinses with decontamination agents and water. Equipment that is not in direct contact with material that is sampled will be washed or wiped clean and rinsed with water. These procedure can be expanded to include additional or alternate wash/rinse steps designed to remove specific target analytes/compounds, if required by site-specific work plans or as directed by a particular client.

4 Cautions

The decontamination of field and sampling equipment will generate one or more waste streams, some of which could be potentially hazardous waste. All wastes will be handled in accordance with E & E SOP ENV 3.26, Handling Investigation-Derived Wastes, as well as project planning documents.

Decontamination agents, including water, detergents, acids, and solvents, can be potentially damaging to some equipment and instrumentation. Care should be taken to ensure that the decontamination process is compatible with the equipment/materials being decontaminated.

Decontamination agents, including waters, detergents, acids, and solvents, must be stored in their original containers or in clearly marked secondary containers onto which information from the original label has been transferred. The secondary labeling should include reagent name, source, date opened/transferred, and expiration date, as well as any applicable hazardous labels, and should be consistent with the Occupational Safety and Health Administration Hazard Communication standard in 29 Code of Federal Regulations (CFR) 1200.

5 Equipment and Supplies

Project planning documents will provide direction on specific decontamination equipment and supplies. The following equipment and supplies are commonly used for the routine decontamination of sampling and field equipment for a broad-scale field sampling program:

- Galvanized steel or similar wash basins;
- Plastic buckets (5-gallon);
- Long-handled brushes;
- Spray/squeeze bottles;
- Non-phosphate detergent (e.g., Alconox™ or Liquinox™);
- Pesticide-grade (or equivalent) organic solvents (e.g., methanol, hexane, or other) as specified in the planning documents;
- Ten percent, by volume in deionized water, nitric acid (ultrapure) (used when metals are a target field analyte);
- Potable water;
- Deionized water (e.g., American Society for Testing and Materials [ASTM] Type II);
- Organic-free water;
- Plastic sheeting for ground cover;
- Paper towels;
- Aluminum foil;
- Trash bags;
- Waste collection drums (if required);
- Protective clothing appropriate for conducting decontamination (including safety glasses or splash shield, splash apron, and nitrile or neoprene gloves); and
- Decontamination verification supplies (e.g., samples bottles for equipment rinsate blank collection, wipes for wipe sampling).

6 Procedure

6.1 General Decontamination Considerations

To minimize decontamination, E & E personnel should follow best practices to minimize contamination of equipment and cross-contamination of cleaned equipment. Measures to minimize contamination include:

- Designate an exclusion zone that isolates areas of contamination from clean areas of the site. Between the exclusion zone and support zone, a contamination reduction zone should be established, within which decontamination activities will be conducted;
- Employ work practices that minimize contact with hazardous or toxic substances (e.g., avoid areas of obvious contamination, avoid touching potentially contaminated materials);

- Use plastic to cover certain parts of monitoring and sampling equipment;
- Use disposable protective apparel and disposable sampling equipment;
- Keep contaminated and uncontaminated equipment and supplies segregated from each other;
- Ensure that decontamination wastes and other investigation-derived wastes are appropriately contained and containerized;
- Use disposable towels to clean the outer surfaces of sample bottles after sample collection; and
- Enclose sources of contamination in plastic sheeting or other barriers.

Because some practices to minimize decontamination can result in more waste to manage (e.g., using disposable sampling implements), it is important to balance decontamination and waste management plans and procedures. The proper balance will be driven by the field investigation tasks and the nature of the contaminants on site.

Potable water, which can be used for certain decontamination steps, can be obtained from a municipal or treated water system. The use of an untreated water supply is not an acceptable substitute for potable water.

The use of distilled, deionized, or ultrapure water is typically acceptable for decontamination of sampling equipment provided that the water has been verified by laboratory analysis to be analyte-free. Analyte-free water is commonly available from commercial vendors and sometimes can be obtained from the project analytical laboratory. Distilled or deionized water available from local grocery stores and pharmacies is generally not acceptable for final decontamination rinses. Analyte-free water that has been stored in unsealed containers or stored at a contaminated site for a prolonged time period also should not be used for final decontamination rinses because the water could have absorbed atmospheric contaminants over time.

The use of solvent rinses (e.g., hexane, methanol, acetone, nitric acid) as part of a decontamination protocol must balance the goals of the decontamination (i.e., to effectively remove the site contaminant as well as other contaminants with the potential to cross-contaminate the investigative samples) with the potential detriment of introducing a contaminant similar to that being investigated (e.g., using hexane as a decontamination solvent would not be advised if hexane is a site contaminant of interest).

6.2 Decontamination Procedure for Equipment in Direct Contact with Sample

Routine decontamination steps for equipment that directly contacts samples are described below.

1. Physically remove gross contamination from equipment by abrasive scraping and/or brushing.
2. Wash equipment with non-phosphate detergent (e.g., Alconox™ or Liquinox™) in potable water.
3. Rinse equipment with potable water.
4. Rinse equipment with deionized water.
5. Decontamination step if sampling/analyzing for metals:

   a. If specified in project planning documents, rinse with 10% nitric acid solution. Nitric acid solution is made from reagent grade nitric acid and deionized water. If equipment is comprised of low-carbon steel, then a 1% nitric acid solution would typically be used.
   b. Rinse equipment with deionized water (a water rinse should always follow an acid rinse).
6. Decontamination step if sampling/analyzing for high levels of organic constituents:
   a. If specified in project planning documents, rinse with specified organic solvent. In general, use a methanol rinse to dissolve and remove soluble (polar) organic contaminants for high-concentration samples, and use a hexane rinse to dissolve and remove waste lubricating oils, tars, and bunker fuels (non-polar organics) for high-concentration samples.
   b. Rinse equipment with deionized, organic-free water,
7. Air dry the equipment.
8. If a rinsate blank sample is specified in project planning documents for verification of decontamination effectiveness, the sample should be collected from sampling equipment at this step.
9. Air dry the equipment again if necessary.
10. Wrap decontaminated equipment in aluminum foil or plastic if the equipment will not be used immediately. Determine the best material to wrap equipment with based on the site contaminants of interest (e.g., the use of plastic would be minimized if sampling for volatile and extractable organics).
11. Containerize decontamination wastes that require testing and/or regulated disposal. Dispose of all wastes in conformance with applicable regulations as defined in the project planning documents.

6.3 Decontamination Procedure for Pumps and Water Quality Meters

Pumps and meters with internal parts that come into direct contact with samples often cannot be thoroughly or directly decontaminated. Consult the manufacturer's guidelines before decontaminating such equipment, to safeguard against damaging it. General decontamination steps are described below.

1. Physically remove visible contamination from equipment by brushing the outside of the equipment or wiping with a dry or damp paper towel.
2. Rinse with or pump acceptable decontamination agents through the equipment.
3. Rinse with or pump potable water through the equipment.
4. Rinse with or pump deionized water through the equipment..
5. Air dry the equipment.
6. If exterior surfaces have not been in direct contact with sample, follow the decontamination procedure described in Section 6.4.
7. If a rinsate blank sample is specified in project planning documents for verification of decontamination effectiveness, the sample should be collected from the equipment at this step.

8. Air dry the equipment again if necessary.
9. Wrap decontamined equipment in aluminum foil or plastic if the equipment will not be used immediately. Determine the best material to wrap equipment with based on the site contaminants (e.g., the use of plastic would be minimized if sampling for volatile and extractable organics).
10. Containerize decontamination wastes that require testing and/or regulated disposal. Dispose of all wastes in conformance with applicable regulations as defined in the project planning documents.

6.4 Decontamination Procedure for Equipment Not in Direct Contact with Sample

Field equipment that does not come into direct contact with samples may be potentially contaminated by exposure to contaminants in dust, by inadvertent contact with contaminated materials, or otherwise. Such equipment could include ambient and air monitoring instruments, tools, generators, computers, and other reusable supplies. In this case, the goal of the decontamination is to remove the site contaminant for health and safety reasons; potential cross-contamination of samples caused by improper decontamination is not a concern. Because this type of equipment often cannot be thorough or directly decontaminated with standard decontamination agents or methods, consideration should be given to discarding the equipment if there is any question regarding whether the decontamination described below is adequate. Consult the manufacturer's guidelines before decontaminating such equipment, to safeguard against damaging it. General decontamination steps are described below.

1. If equipment has tubing or other removable or disposable components (such as with air monitors), they should be removed if practicable and handled separately from the rest of the equipment. It may be possible to thoroughly decontaminate separate parts using the steps in Sections 6.2 or 6.3, or discard them as contaminated waste.
2. Physically remove visible contamination from the outside of the equipment by brushing it or wiping with a dry or damp paper towel.
3. Wash any watertight parts with detergent and water as described in Sections 6.2 and 6.3.
4. Air dry the equipment.
5. Use canned air to dust off computer keyboards and other electronics.
6. Containerize decontamination wastes that require testing and/or regulated disposal. Dispose of all wastes in conformance with applicable regulations as defined in the project planning documents.

6.5 Decontamination Procedure for Heavy Equipment

For heavy equipment such as drill rigs, excavators, loaders, and direct-push technology samplers, a decontamination pad should be established by the subcontractor. Decontamination of heavy sampling equipment (e.g., augers, split spoon samplers) typically includes a steam cleaning and/or high-pressure water wash step after gross contamination is removed by detergent and brushing. Equipment should be final-rinsed and air dried. If a wipe or rinsate sample is specified in project planning documents for verification of decontamination effectiveness, the sample should be collected from equipment after these steps.

6.6 Decontamination Procedure for Equipment at a Radiation Site

For equipment used at sites where radioactive materials are contaminants of concern, the decontamination steps are similar to those described in Sections 6.2 through 6.5, with a few special considerations. Radiation contamination monitoring is used to help locate contamination and guide the success of the decontamination process. The liberal use of water as a decontamination agent is often minimized, where practicable, because of the expense that can be incurred with disposing of radioactively contaminated decontamination water. Containerized decontamination wastes must be evaluated for radioactive content and disposed of appropriately depending on their content. Specific requirements will be included in the project planning documents.

7 Quality Assurance/Quality Control

Prior to inititating fieldwork, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and SHASP) will be reviewed by field personnel to understand the equipment decontamination procedures that have been specified to meet project DQOs. The project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs, including the collection of equipment rinsate blanks and similar QC samples intended to evaluate the effectiveness of decontamination. An equipment rinsate blank typically consists of passing analyte-free water through or over a fully decontaminated sampling device, collecting that water, and analyzing it to assess whether the specified decontamination steps thoroughly removed contaminants of interest and confirm that samples are not being cross-contaminated from unclean equipment.

In cases where it is not feasible to pass water through or over a sampling device or piece of equipment, a wipe sample can be used. A wipe sample typically consists of an analyte-free absorbent material like paper, cloth, glass fiber material, or filter paper that is wiped over the decontaminated surface and analyzed to evaluate the effectiveness of decontamination.

8 Health and Safety

Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the Corporate Health and Safety Program.

Unique hazards associated with decontamination activities include the use of hazardous decontamination agents, the use of steam or high-pressure water cleaning systems, working around heavy equipment (pinch or crush potential), and the generation of potentially hazardous wastes.

Exposure to hazardous decontamination agents is controlled by practices such as contamination avoidance, the use of appropriate personal protective equipment, and proper handling and storage of the agents and wastes, as specified in the SHASP and other project planning documents.

Safety Data Sheets should be available on site for all hazardous decontamination agents, in accordance with the requirements of 29 CFR 1200, Hazard Communication.

Decontamination procedures that employ steam or high-pressure water systems must be performed following equipment manufacturer’s operating and safety guidelines. Care must be taken when working around and decontaminating heavy equipment, especially equipment that is in motion while entering/exiting the contamination reduction zone or while being cleaned (e.g., when ensuring that all parts of the equipment are decontaminated).

9 Special Project Requirements

Project-specific requirements will be included in the project planning documents.

10 References

American Socity for Testing and Materials. 2015. Standard Practice for Decontamination of Field Equipment Used at Waste Sites. ASTM D5088-15a. West Conshohocken, Pennsylvania.

United States Department of Defense. 2013. *DoD Environmental Field Sampling Handbook.* Revision 1.0. April 2013.

United States Environmental Protection Agency (EPA). Sampling Equipment Decontamination. SOP# 2006, REV.# 0.0. August 11, 1994. Environmental Response Team.

__________. 2015. Field Equipment Cleaning and Decontamination. SESDPROC-205-R3. December 18, 2015. EPA Region 4. Athens, Georgia.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

SAMPLE HANDLING, PACKING, AND SHIPPING

SOP NUMBER: ENV 3.16

REVISION DATE: 2/28/2018 **SCHEDULED REVIEW DATE: 2/28/2023**

Contents

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the handling, packing[1], marking, labeling, and shipping procedures routinely used by E & E field personnel to ship samples from the field to off-site laboratories. Shipping includes transport by air, motor vehicle, or rail.

Samples collected of the following matrices typically would be classified as nonhazardous samples (commonly called "environmental samples"):

- Drinking water, groundwater, and surface water;
- Soil and sediment;
- Air;
- Treated municipal and industrial effluent; or
- Biological specimens (e.g., non-pathogenic plant or animal tissue).

Samples collected from drums, storage tanks, impoundments, and lagoons; from known or suspected contaminated areas; and of leachate may potentially need to be classified as hazardous samples.

This SOP does not address sample collection, which is addressed in other E & E SOPs, and assumes that properly collected, filtered (as applicable), preserved, and labeled samples are presented for shipment.

This SOP also does not address the specific procedures for packing, marking, labeling, documenting, and shipping hazardous samples as United States Department of Transportation (DOT) hazardous materials or International Air Transport Association (IATA) dangerous goods, and directs the reader to E & E's Hazardous Materials/Dangerous Goods Shipping Manual for those steps. The project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan (SHASP) will address the types and degrees of contamination anticipated and also might address certain handling and shipping procedures.

This SOP is intended for use by personnel who have knowledge, training, and experience in the procedures described herein.

E & E SOP DOC 2.1, Field Activity Logbooks, also would typically apply to sample handling, packing, and shipping.

2 Definitions and Acronyms

APHIS	Animal and Plant Health Inspection Service
^{o}C	degrees Celsius
CLP	Contract Laboratory Program
COC	Chain of custody

[1] Although some common vernacular might be to "package" samples, the term "pack" samples is used in this SOP: 1) for alignment with the reference SOPs used to develop this SOP, and 2) to prevent confusion with the definitions in hazmat transport regulations for "packaging," which is the receptacle used to contain a hazardous material, and "package," which is the packaging plus its contents.

DOT	(United States) Department of Transportation
DQO	Data quality objective
EPA	(United States) Environmental Protection Agency
IATA	International Air Transport Association
QA/QC	Quality assurance/quality control
RHTC	Regional Hazmat Transportation Coordinator
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
USDA	United States Department of Agriculture
VOA	Volatile organic analysis

3 Procedure Summary

Properly preserved, containerized, and labeled samples provided by field personnel are maintained under secure custody during sample handling, packing, and shipping. Samples presented for shipment are sealed in plastic bags and secured in a plastic-lined cooler. Double-bagged ice is added to the cooler for samples requiring cold preservation. A chain-of-custody (COC) form is completed in full, carefully cross-checked with the samples in the cooler, and enclosed in the cooler. Shipping papers are completed and attached to the cooler, which is custody-sealed and taped closed. The E & E project manager and designated analytical laboratory are notified daily of impending shipments.

4 Cautions

Cautions related to health and safety are discussed in Section 8.

In order to ship hazardous samples, E & E personnel must have received training consistent with the requirements in Title 49 of the Code of Federal Regulations Part 172 (49 CFR 172) Subpart H. If the samples will be shipped by air, E & E personnel also must have received training consistent with Section 1.5 of the IATA Dangerous Goods Regulations. E & E provides this training to applicable employees. The training includes instruction in the use of E & E's on-line Hazardous Materials/Dangerous Goods Shipping Manual and the role of E & E Regional Hazmat Transportation Coordinators (RHTCs), who provide technical support for hazardous sample shipping. This SOP does not specifically address the requirements to properly pack and ship samples that are a hazardous material/dangerous good.

Soil samples from foreign countries, United States (U.S.) territories (i.e., Puerto Rico, U.S. Virgin Islands, and North Mariana Islands), Hawaii, and certain parts of the U.S. fall under federal quarantine as authorized under 7 CFR 301 and are regulated by the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS). Some areas in the U.S. also are under state or local agricultural quarantine. Soils from these regulated areas may contain bacteria, viruses, fungi, nematodes, invertebrates, or seeds of undesirable plant species that could be harmful to U.S. agriculture or natural resources. The movement of these soils within the continental U.S. is regulated under 7 CFR 330.300, which may impose additional special handling, packing, and shipping requirements. Although the general packing for environmental samples likely will suffice, APHIS may have additional requirements, such as for the use of specialized electronic barcoded shipping labels. The project team should refer to the

USDA APHIS and analytical laboratory requirements before handling, packing, and shipping such samples.

International shipping requirements will apply to samples shipped to or from foreign countries and are not addressed by this SOP.

5 Equipment and Supplies

Project planning documents will provide direction on specific equipment and supplies. The following equipment and supplies are commonly used to handle, pack, and ship samples that are presented for shipment:

- Filtered (as necessary), preserved, containerized, and labeled samples, prepared by the field team;
- Coolers, custody seals, and COC documentation forms (typically provided by the laboratory);
- Electrical tape, clear tape, duct tape, and fiber-reinforced packing tape (strapping tape);
- Resealable plastic bags, typically 1-gallon and 2-gallon sizes; freezer-style is preferable because they are thicker;
- Large plastic bags or drum liners, to line coolers;
- Shock-absorbing packing material (e.g., foam block, bubble wrap);
- Packaged ice (commercially available, typically in sizes such as 7-pound and 20-pound bags); and
- Shipping documentation, consisting of an air waybill (air transport) or bill of lading (ground transport).

6 Procedure

6.1 Prior to Field Activity

The following activities are performed prior to field mobilization.

1. Team personnel will assemble and stage equipment and supplies needed to handle, pack, and ship samples;
2. Temperature blanks (typically tap water-filled 40-milliliter volatile organic analysis [VOA] vials or other containers specified in the sampling and analysis plan) will be prepared for use in the field;
3. The project manager or designee will determine the best mode of transportation and verify available locations and pickup/delivery schedules; and
4. The project manager or designee will coordinate with the assigned analytical laboratory regarding schedule and availability to receive and log in the shipped samples. Laboratory receipt of samples on a weekend or holiday will require additional coordination with the laboratory.

6.2 Sample Custody

Collected samples must be either in the custody of responsible personnel or sealed and secured if samples are being stored or transported. Samples are considered to be secure if they are in a locked area with controlled access or when being transported by approved field personnel, a commercial carrier (such as FedEx or UPS), or an approved courier.

A COC form is used to document who has custody of a sample, when, and any exchange of sample custody between the field, shipper/transporter, and laboratory. The COC form also documents sample information and analysis requirements. The final signed COC form becomes the permanent record for sample collection, requested analyses, and custody for each collected sample.

A custody seal is a specialized adhesive label or tape that is used to seal sample containers and the shipment packaging, which for samples is typically a cooler. Custody seals must be affixed such that the seal will be visibly broken if the containers or cooler are opened or tampered with. An intact custody seal means that the samples and their shipping container have not been accessed during storage or shipping. When the laboratory logs in the samples, they will report the condition of the custody seals on the COC or otherwise in the laboratory analytical report.

6.3 Determining Whether Samples are Hazardous

Trained and competent field personnel (see Section 4) will determine if the samples could be considered to contain hazardous materials (dangerous goods) according to U.S. DOT and/or IATA regulations. If so, the samples will be packed, marked, labeled, documented, and shipped in accordance with those regulations. E & E's online Hazardous Materials/Dangerous Goods Shipping Manual provides guidance concerning shipping hazardous samples, and E & E's RHTCs should be consulted during the process.

Types of samples that likely would be classified as hazardous materials/dangerous goods include:

- Samples collected from waste lagoons, drums, tanks, heavily stained soils, and groundwater contaminated with a non-aqueous phase liquid;
- Known or suspected polychlorinated biphenyl- or dioxin-containing samples;
- Samples preserved with methanol, such as from using a Terra Core™ kit (although such samples can be shipped as an excepted quantity of hazardous material, which has some less rigorous shipping requirements); and
- Some biological specimen samples, such as those known or suspected to contain an infectious agent.

Water samples preserved with acids or bases typically will not be considered hazardous materials/dangerous goods. (The containers of acid or base preservatives themselves would be a hazardous material/dangerous good.)

6.4 Environmental Sample Packing

It is E & E's intent to pack samples securely to prevent damage and leakage during shipment. This is to prevent the loss of samples and the expenditure of funds to re-obtain the samples or for potential emergency response to a leaking package or spill. Liquid samples are particularly vulnerable. Even if a package is classified and transported as a nonhazardous material, transporters (carriers) are not able to know the difference between a package leaking distilled water and a package leaking a hazardous chemical and may react to a spill in an emergency fashion, potentially causing expense to E & E or its clients for the cleanup of the sample material. Therefore, samples are packed in plastic bags with the use of shock-absorbent/cushioning material to help prevent leaking of samples both inside and outside the transport package.

Environmental samples will be packed securely whether the samples are shipped via commercial carrier or courier. Environmental samples are usually shipped in 80-quart, solid outer-shell plastic or metal coolers, although other size coolers may be used if they meet project needs. Disposable, pressed Styrofoam™ coolers must not be used to store or ship samples.

Initial Steps

1. Remove non-applicable labels from the cooler.
2. Seal the cooler drain hole with duct tape or equivalent both inside and outside the cooler to prevent leakage.
3. Assemble the containerized samples that will be shipped in the cooler.
4. Ensure that the sample containers are clean, dry, and labeled (wipe container with a paper towel if the container is not clean or dry).
5. Verify that sample container caps/lids are tight.
6. Apply a custody seal over the cap/lid and then secure the custody seal and cap/lid to the container using fiber-reinforced tape, electrical tape, or equivalent. Do not obscure the sample label with the custody seal or tape.
7. Ensure that each container is fully documented on the COC form. COC forms may be completed electronically or by hand depending on project requirements. E.g., EPA Contract Laboratory Program (CLP) sampling/analysis may require electronically generated and completed COC forms.
8. Place each sample container into a resealable plastic bag.
9. Place at least 1 inch of inert shock-absorbent material (e.g., bubble wrap) in the bottom of the cooler.
10. Line the cooler with a heavy-duty plastic trash bag or drum liner.
11. For samples requiring cold preservation:
    a. Maintain the samples on ice during sample handling and packing.
    b. Fill resealable plastic bags with ice and enclose each bag in a second resealable plastic bag such that the ice is double-bagged. These bags of ice will be needed for the cooler.

Securing Sample Containers in the Cooler

1. The sample containers themselves will typically be secured inside the cooler using one of the following methods intended to prevent container damage or breakage.
    a. Pre-cut foam block insert:
        i. Place the foam block insert (with holes cut for the sample containers) inside the plastic bag.
        ii. Place the containers upright in the holes in the foam block.

b. Bubble wrap or equivalent:

   i. Surround each sample container (including the bottom) with bubble wrap, taping the wrap securely around the container; or place the container in a bubble bag. (Some personnel opt to surround the sample container with bubble wrap before placing the sample container in its resealable bag.)

   ii. Place the containers upright in the plastic bag.

   iii. Fill void spaces with additional bubble wrap or other shock absorbent.

c. Loose material that provides shock absorption and liquid absorption (e.g., small animal bedding material made from recycled paper/wood waste):

   i. Place at least 1 inch of the absorbent material in the bottom of the plastic bag lining the cooler.

   ii. Place each sample container upright inside the plastic bag, maintaining about 3 inches between containers.

   iii. Fill the void spaces around the containers with absorbent to at least half the height of the largest container.

2. For liquid samples packed by methods 1a or 1b above, void spaces in the plastic-lined cooler additionally can be filled with non-combustible, absorbent packing material to absorb any sample liquid should breakage or leakage occur and breach the plastic bags containing the individual samples. Vermiculite or light-weight cat litter should not be used for this purpose because they are dusty, staticky, and difficult to remove from the sample containers and cooler. The animal bedding material described in method 1c above is a suitable material for this purpose, as is cellulose wadding and super-absorbent packets. The use of liquid absorbent is not strictly required, and the consequences of sample container leakage are largely mitigated by following the other steps in this section (e.g., the use of multiple layers of plastic bags).

3. If the samples require cold preservation, fill void spaces with double-bagged ice. The ice should be sufficient to maintain the temperature of the samples to about 4 degrees Celsius (°C), ±2 °C, and also not freeze the samples. Additional ice likely will be needed in warmer climates, during warmer times of the year, and if the samples will not be immediately checked in by the laboratory (such as during weekends or holidays). Samples that do not arrive at the laboratory at the proper temperature might need to be re-collected if analysis of those samples would result in qualified data. Analysis of improperly preserved samples and/or re-collection of samples will result in additional expense to E & E and its client that is far greater than shipping the additional sample coolers that might be needed to accommodate a sufficient quantity of ice.

4. Place a temperature blank inside a resealable plastic bag and place the blank inside the cooler.

5. Close and seal the plastic bag lining the cooler and affix a custody seal. This custody seal is an additional layer of custody security in case the cooler is opened and inspected by the U.S. Transportation Security Administration or by customs for international shipments, or the outer custody seals on the cooler fail.

Final Steps

1. Complete and sign the COC form, maintain the required copies, place it in a resealable plastic bag or pouch, and tape the bag/pouch to the inside of the cooler lid.

2. Close the cooler. Place custody seals in two locations along the top of the cooler such that the cooler cannot be opened without breaking the seals. Do not place the custody seals on the hinged side of the cooler lid.
3. Secure the cooler with strapping tape or equivalent over the hinges, over the custody seals, and and around the entire cooler.

6.5 Marking, Labeling, and Shipping

Marking, labeling, and shipping will be performed in accordance with the requirements of the carrier (e.g., Federal Express) or courier that will be used.

Each cooler of environmental (nonhazardous) samples will be marked with an address label showing the name and address of the sender and recipient. “This Side Up” labels will be applied to at least two sides of the cooler.

Shipping documentation will consist of an airbill for air transport or a bill of lading for ground transport, which will be affixed to the lid of the cooler. A hazardous materials/dangerous goods shipper’s declaration is not used when shipping environmental (nonhazardous) samples.

The field team will notify the E & E project manager and the recipient laboratory daily of impending shipments. The E & E project manager will notify E & E’s client if required. The field team or project manager will follow up daily using shipper tracking numbers and review of laboratory log-in documentation to ensure that each shipment of samples has been received as scheduled and logged in immediately upon receipt, and that samples requiring cold preservation have been placed in cold storage upon receipt at the laboratory.

7 Quality Assurance/Quality Control

The program/project manager will identify personnel for the field team who have knowledge, training, and experience in the sample handling, packing, and shipping activities to be conducted.

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, SHASP) will be reviewed by team personnel to understand the procedures that have been specified to result in samples that will meet project data quality objectives (DQOs). Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs. QA/QC steps important to sample handling, packing, and shipping have been incorporated into the procedures in Section 6 and include steps such as the following:

- Maintaining samples under secure custody;
- Completely and accurately filling out COC forms and diligently checking the samples in the cooler against the samples listed on the COC form;
- Using sufficient ice to maintain appropriate sample temperatures during the shipping of samples requiring cold preservation;
- Coordinating with the recipient laboratory regarding scheduled sample shipments; and
- Following up with the laboratory to ensure that samples have been received as scheduled and logged in, and that samples requiring cold preservation have been placed in cold storage upon receipt at the laboratory.

8 Health and Safety

Prior to entering the field, personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the Corporate Health and Safety Program.

Unique hazards associated with sample handling, packing, and shipping include handling containerized samples that have been preserved with acids, bases, or other chemicals, and the ergonomic hazards of lifting heavy coolers of samples. Exposure to these hazards will be controlled by following the SHASP and the hazard control measures and safe work practices it prescribes, such as wearing gloves and using safe lifting practices.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents. Programs such as the EPA CLP may have additional, specific proceedures for handling, packing, and shipping samples.

10 References

United States Environmental Protection Agency (EPA). 2014. *Sampler's Guide. Contract Laboratory Program Guidance for Field Samplers.* OSWER 9200.2-147. EPA-540-R-014-013. Office of Superfund Remediation and Technology Innovation. October 2014.

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END OF SOP

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STANDARD OPERATING PROCEDURE

COLLECTING SOIL AND SEDIMENT SAMPLES FOR VOC ANALYSIS

SOP NUMBER: ENV 3.25

REVISION DATE: 7/30/2018 **SCHEDULED REVIEW DATE: 7/30/2023**

Contents

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for collecting and containerizing soil and sediment samples for off-site analysis of volatile organic compounds (VOCs) in accordance with United States Environmental Protection Agency (EPA) SW-846 Methods 5035, 5035A, or similar. These collection procedures are designed to minimize disturbance of the sample and loss of VOCs. The purpose of soil and/or sediment sampling may range from simple reconnaissance to complex sampling programs. Specific sampling procedures may vary depending on the data quality objectives (DQOs) identified in project planning documents. Both low-concentration and high-concentration VOC sampling procedures are provided herein.

This SOP does not address the procedures to initially obtain the soil or sediment material, which would be collected using hand implements, augers, corers, or heavy equipment such as split-spoon samplers. This SOP addresses only the specific methods to properly collect and containerize the subsample (or aliquot) being submitted for VOC analysis.

This SOP is intended for use by personnel who have knowledge, training, and experience in the field sampling activities being conducted.

Other E & E SOPs that would typically also apply to the collection of soil and sediment samples for VOC analysis include the following:

- DOC 2.1, Field Activity Logbooks;
- ENV 3.8, Aquatic Sediment Sampling;
- ENV 3.13, Surface and Shallow Subsurface Soil Sampling;
- ENV 3.15, Sampling and Field Equipment Decontamination;
- ENV 3.16, Environmental Sample Handling, Packing, and Shipping;
- ENV 3.26, Handling Investigation-Derived Wastes; and
- GEO 4.7, Borehole Installation and Subsurface Soil Sampling.

2 Definitions and Acronyms

°C	Degrees Celsius
DI	Deionized
DQO	Data quality objective
E & E	Ecology and Environment, Inc.
EPA	(United States) Environmental Protection Agency
g	gram
µg/kg	micrograms per kilogram (parts per billion)
mL	milliliter
$NaHSO_4$	Sodium bisulfate
QA	Quality assurance
QC	Quality control

SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
VOA	Volatile organic analysis
VOC	Volatile organic compound

3 Procedure Summary

The subsample or aliquot of a soil or sediment sample that is submitted for analysis of VOCs is collected using specialized methods and containers designed to minimize disturbance of the sample and loss of VOCs. Project planning documents will specify methods appropriate for the low and/or high concentrations of VOCs anticipated to be in the samples. The methods and containers typically consist of specialized samplers such as Terra Core™ samplers, En Core™ samplers, or equivalent; sample preparation or preservation solutions such as deionized (DI) water, sodium bisulfate ($NaHSO_4$), or methanol; and volatile organic analysis (VOA) vials or jars.

4 Cautions

Cautions related to health and safety are discussed in Section 8.

Standard measures, such as the use of disposable gloves, should be used to avoid cross-contamination of samples between sample locations.

The quantities of methanol and $NaHSO_4$ used as preservatives in some of the sampling methods are likely considered to be hazardous materials (as defined by the United States Department of Transportation) or dangerous goods (as defined by the International Air Transport Association), and therefore will require transportation in accordance with proper regulations. An E & E hazardous materials shipping specialist and E & E's Hazardous Materials Shipping Manual should be consulted for guidance.

5 Equipment and Supplies

The following is a general list of equipment and supplies that applies to the sampling methods discussed in Section 6. A detailed list of equipment and supplies will be prepared based on the project planning documents.

- Terra Core™ or En Core™ samplers or equivalent;
- Laboratory-provided or vendor-provided pre-preserved VOA sample vials (typically pre-weighed, labeled, with preparation solution, preservative, stir bars, and other analysis-specific components);
- 40-milliliter (mL) VOA vials;
- 2- or 4-ounce Teflon-lined, septum-sealed VOA jars;
- Plastic 5-mL disposable syringes, where the barrel outside diameter is less than the sample vial neck inside diameter, or sample coring devices supplied by the laboratory;
- Cutting tool (for syringes if not pre-cut);
- If samples are weighed in the field, then:
  - Portable analytical balance (range 0 to 100 grams [g]) and capable of weighing to ±0.01 g,

  - Calibration weight set (1 to 50 g), and
  - Weighing dishes (disposable);

- Specialized quality control samples provided by the project laboratory, e.g., purified-grade sea sand trip blanks or field blanks; and
- Supporting equipment and supplies, e.g., disposable gloves, field logbook, sample custody and documentation supplies, decontamination supplies, sample packaging/shipping supplies, safety supplies, and waste handling supplies.

6 Procedure

6.1 General Sampling Considerations

The E & E project manager will coordinate with qualified project laboratories and vendors to ensure that the correct sampling procedures and equipment are used in accordance with project DQOs, project planning documents, and laboratory requirements. VOC sample vial size, type, and style may vary by laboratory.

The sampling method specified in the project planning documents takes into account whether low-concentration VOCs (generally in the range of approximately 0.5 to 200 micrograms per kilogram [µg/kg]) or high-concentration VOCs (greater than approximately 200 µg/kg) are anticipated. Collection methods suitable for the analysis of both low and high concentrations of VOCs are used if the VOC concentrations are unknown.

Soil and sediment samples collected for VOC analysis might be able to be collected directly from the enviroment, but most often are collected by subsampling the soil/sediment initially collected using some type of sampling equipment (e.g., hand implements, augers, corers, or split spoons). Soil and sediment samples collected and prepared for VOC analysis are collected as soon as possible after the soil or sediment material is initially collected and before any homogenization of that material.

Dedicated laboratory- or vendor-supplied equipment such as Terra Core™ or En Core™ (or equivalent) sampling tools do not require decontamination prior to use and prevent sample cross-contamination. Other field equipment used to collect soil/sediment samples for VOC analysis should be cleaned/decontaminated or disposed of between sampling locations to prevent cross-contamination between samples. Chemical solvents should not be used as decontamination agents because they could result in false positive VOC results for the collected sample if the solvents are not rinsed off well enough.

If not otherwise specified by the project planning documents, a separate and additional sample for percent moisture determination should be obtained for each sample location by filling a standard 40-mL VOA vial or a 2- or 4-ounce jar with the same material being submitted for VOC analysis.

6.2 Low-Concentration Vial Sampling (DI Water or Preservative)

This procedure is the most common one used to collect a soil or sediment sample for the analysis of low concentrations of VOCs. The procedure uses laboratory-provided VOA vials containing either 5 mL of DI water or a small amount of $NaHSO_4$ preservative ($NaHSO_4$ slightly acidifies the sample and reduces biological activity) and a sample collection/coring (e.g.,Terra Core™) device. For most sampling under this procedure, E & E typically uses vials containing DI water.

Typically, the laboratory or vendor provides pre-weighed unpreserved (DI water) or preserved ($NaHSO_4$) VOA vials, and sample weights are estimated based on sample volumes defined by the coring device volume. Sample weights will vary depending on the soil/sediment sample density. If sample weights are too low, analytical detection limits may be affected and more accurate determination of sample weights may be required, as per Step 1, although Step 1 is seldom required.

1. **Calculate the sample volume required for sample collection (optional)**

   If the laboratory does not provide pre-weighed vials or if the project DQOs require accurate determination of sample weight and volume, then a portable balance and work station are set up in the field. The following steps are followed to weigh the vials and determine an appropriate sample weight.

   a. Calibrate the analytical balance daily before use. Check the balance with four weights ranging from 1 to 50 g. Record readings against expected values in the logbook. Readings must be within $\pm$ 0.01 g of the expected value or the balance must be checked and recalibrated.

   b. To determine or verify a laboratory- or vendor-provided VOA vial weight, place the sample vial with DI water or $NaHSO_4$, cap, stirring bar, etc. on the balance. If the vial weight is not within $\pm$ 0.1 g of the laboratory-reported or acceptable weight, do not use the vial.

   c. Prepare a sample corer by cutting the tip off of a 5-mL plastic syringe or use the sample corer provided by the laboratory. The diameter of the syringe barrel needs to be less than the diameter of the sample vial.

   d. Determine the sample volume necessary to provide a 4.5 to 5.5 g sample.

   e. Collect approximately 5 g of sample using the syringe barrel or Terra Core™ sampler.

   f. Extrue the sample onto a tared weighing dish and weigh it. If the sample weight is between 4.5 and 5.5 g, then proceed to Step 2. If the sample weight is outside of the range of 4.5 to 5.5 g, dispose of the weighing dish and sample. Adjust the sample volume, recollect, and reweigh a sample expected to be within the required range. Once the correct sample volume has been determined, proceed to Step 2.

2. **Sample Collection**

   a. Confirm that a sample vial weight has been provided by the laboratory or vendor or otherwise determined, such as via Step 1.

   b. Inspect the sample vials and verify that the sample stir bar is present and that water or solution levels are consistent. If it appears that water or solution is lost from the vial, do not use it.

   c. Prepare a sample corer by cutting the tip off of a 5-mL plastic syringe or use the sample corer (e.g., Terra Core™) provided by the laboratory. The diameter of the syringe barrel needs to be less than the diameter of the sample vial.

   d. Collect the calculated or desired sample volume by driving the coring device into a representative section of the soil or sediment material.

   e. Carefully extrude the soil/sediment into the sample vial taking care not to lose any water or solution from the vial. If water or solution is inadvertently pushed out of the vial, then discard the vial and re-collect the sample.

f. Wipe the exterior of the sample vial and cap. Ensure that no soil is on the vial top and that a tight seal is formed when capping the vial.

g. Soil/sediment samples that contain carbonate material may effervesce on contact with $NaHSO_4$. After capping the vial, check the sample and solution. If there is significant effervescence, discard the sample and use a vial containing DI water. Note the amount of effervescence in the field logbook and any decisions made to retain the use of $NaHSO_4$ vials or switch to DI water vials. The amount of effervescence for retained samples will be reviewed during data validation because effervescence can lead to vial overpressure and potential loss of VOCs during sampling. Allow any discarded effervescing vials to vent slightly prior to disposal to prevent the vial from breaking.

h. For each sample, collect into additional vials using the same coring device and from the same area of the material. The number of vials per sample will be determined with the laboratory, but at least two to three vials are typically collected.

i. Place the vials for the same sample into one sealable plastic bag. A custody seal can be applied to the bag closure instead of each vial.

j. If a percent moisture determination sample has not yet been collected, collect and place one separate standard percent moisture determination soil/sediment aliquot into a 40-mL VOA vial or a 2- or 4-ounce jar. Place the sample in a sealable plastic bag.

k. Place the soil samples on ice (4±2°C). Lay the vials on their side so that the septum remains wet on the inside, thereby preventing vapor leaks around it in case any bubbles form. As well, if the sample is later frozen by the laboratory, being on its side allows water to expand into the flexible septum rather than break the vial.

If the sample is extruded into DI water, the vial may be cooled to 4±2°C for no more than 48 hours, after which the sample must be analyzed or frozen to < -7°C by the laboratory. The holding time between collection and analysis in this case is typically 14 days, if frozen. The holding time between collection and analysis for samples preserved with $NaHSO_4$ is typically 14 days.

6.3 High-Concentration Vial Sampling (Methanol-Preserved)

This procedure can be used to collect a soil or sediment sample for the analysis of high concentrations of VOCs. Collection and analysis of samples for high concentrations of VOCs is typically conducted in addition to that for low concentrations of VOcs in cases where VOC concentrations are unknown or high VOC concentrations are expected. Analytical detection limits for high-concentration sampling and analysis may be elevated by several orders of magnitude above low-concentration detection limits. Methanol is used in this procedure as both a preservative and analytical extraction solution.

Collect the sample as follows:

1. Use the steps in Section 6.2 Step 1 if needed to determine the sample volume to be collected, to verify laboratory- or vendor-provided vial weights, or if pre-weighed VOA vials are not provided.
2. Use a sample vial with methanol, cap, stirring bar, etc. The methanol will be analyzed directly on the instrument for very high-concentration samples.

3. Prepare a sample corer by cutting the tip off of a 5-mL plastic syringe or use the sample corer (e.g., Terra Core™) provided by the laboratory. The diameter of the syringe barrel needs to be less than the diameter of the sample vial.
4. Collect the calculated or desired sample volume (same as the low-concentration aliquot) by driving the coring device into a representative section of the soil or sediment material.
5. Carefully extrude the soil/sediment into the sample vial.
6. Wipe the exterior of the sample vial and cap. Ensure that no soil is on the vial top and that a tight seal is formed when capping the vial.
7. For each sample, collect into a second vial using the same coring device and from the same area of the material.
8. Place the vials for the same sample into one sealable plastic bag. A custody seal can be applied to the bag closure instead of each vial.
9. If a percent moisture determination sample has not yet been collected, collect and place one separate standard percent moisture determination soil/sediment aliquot into a 40-mL VOA vial or a 2- or 4-ounce jar. Place the sample in a sealable plastic bag.
10. Place the soil samples on ice (4±2ºC). Lay the vials on their side so that the septum remains wet on the inside, thereby preventing vapor leaks around it in case any bubbles form.

The holding time between collection and analysis for vial samples preserved with methanol is typically 14 days.

6.4 Low- or High-Concentration Vial Sampling (Unpreserved)

This procedure can be used to collect a soil or sediment sample for the analysis of low or high concentrations of VOCs using no preservation or preparation solution (i.e., no DI water or chemical preservative) in the field. The soil or sediment is extruded into a pre-weighed and unpreserved vial. The laboratory will add the appropriate amount of extraction solution to the sample as required for low-concentration analysis (DI water) or high-concentration analysis (methanol).

Collect the sample as follows:

1. Use the steps in Section 6.2 Step 1 if needed to determine the sample volume to be collected, to verify laboratory- or vendor-provided vial weights, or if pre-weighed VOA vials are not provided.
2. Use a sample vial, cap, stirring bar, etc.
3. Prepare a sample corer by cutting the tip off of a 5-mL plastic syringe or use the sample corer (e.g., Terra Core™) provided by the laboratory. The diameter of the syringe barrel needs to be less than the diameter of the sample vial.
4. Collect the calculated or desired sample volume by driving the coring device into a representative section of the soil or sediment material.
5. Carefully extrude the soil/sediment into the sample vial.
6. Wipe the exterior of the sample vial and cap. Ensure that no soil is on the vial top and that a tight seal is formed when capping the vial.

7. For each sample, collect into two more vials using the same coring device and from the same area of the material.
8. Place the vials for the same sample into one sealable plastic bag. A custody seal can be applied to the bag closure instead of each vial.
9. If a percent moisture determination sample has not yet been collected, collect and place one separate standard percent moisture determination soil/sediment aliquot into a 40-mL VOA vial or a 2- or 4-ounce jar. Place the sample in a sealable plastic bag.
10. Place the soil samples on ice (4±2ºC).

The vial may be cooled to 4±2ºC for no more than 48 hours, after which the sample must be analyzed or frozen to < -7°C by the laboratory. The holding time between collection and analysis for this type of VOC sample collection is typically 14 days, if frozen.

6.5 High-Concentration Bulk Sampling (Unpreserved)

This procedure can be used to collect a soil or sediment sample for the analysis of high concentrations of VOCs. Collection and analysis of samples for high concentrations of VOCs is typically conducted in addition to that for low concentrations of VOCs in cases where VOC concentrations are unknown or high VOC concentrations are expected. Analytical detection limits for high-concentration sampling and analysis may be elevated by several orders of magnitude above low-concentration detection limits.

Collect the sample as follows:

1. Completely fill a septum-sealed 2- or 4-ounce VOA sample container with soil or sediment, leaving as little headspace as possible.
2. For each sample, fill a second container using the same implement and from the same area of the material. This additional quantity is most needed if only high-concentration samples are being collected under the sampling program.
3. Apply a custody seal to each sample container and place each in a sealable plastic bag.
4. If a percent moisture determination sample has not yet been collected, collect and place one separate standard percent moisture determination soil/sediment aliquot into a 40-mL VOA vial or a 2- or 4-ounce jar. Place the sample in a sealable plastic bag.
5. Place the soil samples on ice (4±2ºC).

The holding time between collection and analysis for bulk soil or sediment samples is typically 14 days. These samples should not be frozen.

6.6 En Core™ Sampling

The En Core™ sampler can be used to collect a soil or sediment sample for the analysis of low or high concentrations of VOCs. The En Core™ sampler consists of a sampler unit, T-handle, and cap. The collected sample is not required to be chemically preserved in the field. The En Core™ sampler works best in cohesive granular materials and may not be appropriate for sample collection of some matrices (e.g., dry sands).

Collect the sample as follows:

1. Remove the sampler from the sealed foil package.
2. Insert the sampler in the T-handle, turn, and allow the locking arm to click into place.

3. Place the sampler over the soil sample. The view hole should be open.
4. Push down until you see a gasket in the view hole. Twist the sampler and remove it from surrounding soil.
5. Check that the sampler is full of soil. Place the cap over the sample unit and lock it into place.
6. Release the locking arm and remove the sampler unit from the T-handle.
7. Label the sampler unit with the sticker located on the foil pouch.
8. Return the labeled sampler unit to the foil pouch and seal it.
9. For each sample, collect into two additional sampler units from the same area of the material.
10. If a percent moisture determination sample has not yet been collected, collect and place one separate standard percent moisture determination soil/sediment aliquot into a 40-mL VOA vial or a 2- or 4-ounce jar.
11. Place the samples on ice (4±2^{o}C). (The pouched samples may be frozen prior to shipping, although this is seldom feasible in the field.)
12. Decontaminate the T-handle between unique sample locations.

The holding time between collection and analysis for samples collected using an En Core™ (or equivalent) sampling device is typically 48 hours.

7 Quality Assurance/Quality Control

The project manager should identify personnel for the field team who have knowledge, training and experience in the soil/sediment sampling activities to be conducted. One member of the field team should be designated as the lead for soil/sediment sampling conducted for VOC analysis and will be responsible, with support from other field personnel, for implementing the procedures in this SOP. The project manager should also identify additional personnel, if necessary, to complete ancillary procedures, e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal.

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan [SHASP]) will be reviewed by field personnel to understand the sampling procedures that have been specified to result in soil/sediment samples and VOC data that meet project DQOs. Project planning documents will define the quality assurance/quality control (QA/QC) procedures necessary to meet project DQOs, including the sampling protocol for QC samples such as trip blanks, equipment rinsate blanks (to assess the effectiveness of field decontamination methods for non-dedicated and non-disposable equipment), field duplicates, and other types of field and analytical QC samples. Trip blank samples for soil and sediment VOC analyses are typically prepared by the project laboratory using pre-cleaned sea sand in appropriate vials and/or samplers. For other types of field blanks prepared in the field, pre-cleaned sea sand provided by the project laboratory can be used, following the same sample collection procedures in this SOP. Field duplicates are typically collected from at least one location and treated as separate samples, blind to the laboratory. Certain field blanks should be processed at the site location to account for ambient and other site-specific conditions.

The E & E project manager will coordinate with qualified project laboratories and vendors to ensure that the correct procedures and equipment for collecting samples for VOC analysis are used in accordance with project DQOs and planning documents.

The use of different procedures to collect soil/sediment samples for VOCs within the same project (or between projects) can affect the comparability of the VOC data if samples collected by different procedures are evaluated together.

The small size of the samples collected and analyzed by the procedures addressed in this SOP can inherently limit the representativeness of the sample data when compared to larger, homogenized samples. If the collocated sample portions collected for each sample do not appear to be homogeneous, the field sampler should attempt to sample one type of material to the extent practicable and note this in the field logbook. Because field duplicate samples for VOC analysis also are collocated, and are not homogenized replicates, some degree of field variability is inherently added that may result in less precision between field duplicate sample results than is seen when homogenized samples are analyzed as field duplicates.

8 Health and Safety

Prior to entering the field, all field personnel will acknowledge in writing that they have read and understand the SHASP, which will be in compliance with the E & E Corporate Health and Safety Program.

Unique hazards associated with collecting soil and sediment samples for VOC analysis consist of:

- The use and presence of chemical preservatives such as $NaHSO_4$ and methanol in pre-preserved sample containers. The field team will wear the personal protective equipment specified by the SHASP, handle the sample containers with care, and collect and process such samples in a well-ventilated area.
- The potential for contamination of soil and sediment with site contaminants such as chemical, radioactive, and/or pathogenic biological material. The SHASP will provide instruction for safe handling of contaminated site soils and sediment.

9 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

10 References

United States Department of Defense (DoD). 2013. *DoD Environmental Field Sampling Handbook*. Revision 1.0. April 2013.

United States Environmental Protection Agency (EPA). 1984. *Characterization of Hazardous Waste Sites – A Methods Manual: Volume II. Available Sampling Methods*, *Second Edition.* December 1984. EPA-600/4-84-076. Environmental Monitoring Systems Laboratory. Las Vegas, Nevada.

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END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

HANDLING INVESTIGATION-DERIVED WASTES

SOP NUMBER: ENV 3.26

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Contents

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures used by E & E for handling investigation-derived waste (IDW). Procedures for handling non-hazardous and hazardous categories of IDW are provided. IDW commonly includes:

- Cuttings from drilling (e.g., soil, sediment);
- Rotary drilling fluids (e.g., muds or solutions);
- Groundwater obtained through well development or well purging;
- Spent decontamination/cleaning fluids (e.g., solvents, wash water);
- Used personal protective equipment (PPE) (e.g., protective suits, gloves);
- Disposable equipment and materials (e.g., sampling equipment, containers); and
- Used packing and shipping materials.

This SOP provides references to certain federal regulatory standards for hazardous waste management and does not address state or local regulatory standards or requirements. The contents of regulatory standards for characterizing and transporting hazardous waste are outside the scope of this SOP. Users of this SOP are required to comply with applicable regulations.

This SOP does not apply to IDW associated with explosive, radioactive, mixed (hazardous and radioactive), or pathogenic wastes or to projects outside of the United States.

The IDW expected to be generated during an investigation and the procedures to manage it should be identified in project planning documents.

This SOP for handling IDW is intended for use by personnel who have knowledge, training, and experience in field activities that generate IDW and how that IDW is handled.

2 Definitions and Acronyms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DOT	(U.S.) Department of Transportation
E & E	Ecology and Environment, Inc.
EPA	(U.S.) Environmental Protection Agency
Hazardous waste	Discarded material that is dangerous or potentially harmful to human health or the environment. Hazardous waste can be solid, semisolid, liquid, or contained gaseous material. EPA defines hazardous waste under RCRA as waste that exhibits specific hazardous characteristics, is a listed hazardous waste under the statute, or otherwise meets the definition. For the purposes of this SOP, hazardous waste also will include wastes that contain hazardous constituents regulated under CERCLA, TSCA, CWA, and similar regulations.

IDW	Investigation-derived waste, specifically as pertaining to solid or liquid wastes resulting from E & E field activities
Non-hazardous waste	For the purposes of this SOP, non-hazardous waste means traditional garbage or refuse and does not include wastes that meet the RCRA definition of a hazardous waste; wastes that contain hazardous constituents regulated under CERCLA, TSCA, CWA, and similar regulations; or regulated non-hazardous waste such as industrial waste
PPE	Personal protective equipment
RCRA	Resource Conservation and Recovery Act
SHASP	Site-specific health and safety plan
SOP	Standard operating procedure
TDU	Treatment/disposal unit
TSCA	Toxic Substances Control Act
TSD	Treatment, storage, and disposal

3 Procedure Summary

The IDW procedures identified in the project planning documents will vary depending on the site contaminants, site conditions, sampling procedures, and applicable regulatory requirements. Non-hazardous and hazardous wastes will be handled separately. IDW management requires pre-investigation planning, on-site IDW waste minimization, IDW waste segregation, and specific IDW handling and disposal depending on the type of IDW that is generated.

4 Cautions

Cautions related to health and safety are discussed in Section 8.

The U.S. Environmental Protection Agency's (EPA's) Resource Conservation and Recovery Act (RCRA) defines hazardous waste and imposes limitations and restrictions on its storage, transport, and disposal. Hazardous wastes may require separate sampling and analysis to determine proper IDW disposition. Because sampling and analysis of wastes can be time-consuming and expensive, best professional judgment combined with knowledge of historical site activities and existing site processes/raw material/waste stream information should be the first source of data in the characterization IDW.

Because hazardous waste transporters move regulated wastes on public roads, highways, rails, and waterways, the EPA and the U.S. Department of Transportation (DOT) jointly developed the hazardous waste transporter regulations, which are found in Title 40 Part 263 of the U.S. Code of Federal Regulations (40 CFR 263). Certain DOT regulations in 49 CFR Parts 100 to 185 also are applicable to the off-site transportation of hazardous IDW.

Other regulations also may apply to IDW handling, including those of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Toxic Substances Control Act (TSCA), Clean Water Act (CWA), and state, local, and tribal entities.

5 Equipment and Supplies

Equipment needed for handling IDW typically includes:

- Fifty-five-gallon drums;
- Five-gallon buckets;
- Labels for drums and buckets;
- Wrench and hammer to secure drum lids;
- Lumber, plastic sheeting, and plywood for creating a temporary storage area;
- Trash bags;
- Sample containers;
- Indelible ink pen/permanent marker for labeling drums/containers;
- Manifests/shipping documents;
- Plastic trash bags; and
- PPE.

6 Procedure

6.1 Planning

Prior to site investigation activities, E & E project personnel will develop appropriate project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, and site-specific health and safety plan [SHASP]), which collectively will address the types of IDW expected to be generated and how that IDW will be managed. Prior to field activities, E & E and subcontractor field personnel are required to review and understand site-specific procedures established for handling IDW.

6.2 Waste Minimization

The generation of IDW should be minimized to reduce the need for handling, storage, and disposal that may result in substantial additional costs yet provide little or no reduction in site risks. Waste minimization will be initiated during site planning by identifying and eliminating site activities that may generate IDW or identifying methods to reduce the generation of IDW. Methods and techniques that will contribute to eliminating or reducing IDW include:

- Replace solvent-based cleaners with aqueous-based cleaners for decontamination of equipment;
- Eliminate solvent use when possible;
- Avoid the generation of excess decontamination liquid (e.g., use less water);
- Limit traffic between clean and hot zones;
- Limit field team contact with site contaminants;
- Minimize the use of disposable equipment and materials;
- Use non-disposable equipment/materials that can effectively be decontaminated and reused;
- Use non-intrusive or minimally intrusive investigation methods and sampling techniques that generate little waste (e.g., direct-push samplers);

- Avoid co-mingling hazardous and non-hazardous wastes;
- Recycle clean and non-hazardous traditional recyclables such as cardboard, paper, metal, and beverage containers; and
- Collect only the amount of sample that is needed.

6.3 Management of Non-hazardous IDW

For the purposes of this SOP, non-hazardous IDW means traditional garbage or refuse and does not include wastes that meet the RCRA definition of a hazardous waste; wastes that contain hazardous constituents regulated under CERCLA, TSCA, CWA, and similar regulations; or regulated non-hazardous waste such as industrial waste.

For non-hazardous IDW comprised of uncontaminated or decontaminated PPE, disposable equipment/materials, paper towels, and other wastes that are known to be non-hazardous, the following procedures are typically employed:

- Render the IDW unusable (e.g., by cutting or tearing the material).
- Double-bag the IDW in plastic bags.
- If the investigation is at an active facility, request permission from the owner/operator to dispose of the non-hazardous waste in the facility's operational trash and recycling receptacles/dumpsters.
- If the investigation is not at an active facility, arrange with the client for the non-hazardous IDW to be disposed of at a permitted municipal solid waste disposal facility.

For non-hazardous IDW comprised of site media like soil cuttings, drilling mud, purge or development water, and decontamination wash water that are known to be non-hazardous, the following procedures are typically employed:

- Spread soil/sediment cuttings around the well or borehole or place the cuttings back in the borehole or excavation.
- Pour groundwater from potable water wells and monitoring wells onto the ground in locations where no environmental impacts are anticipated.
- Pour decontamination water (which may contain low levels of non-phosphate detergents) onto the ground in locations where no environmental impacts are anticipated.
- Pour decontamination water down a sanitary sewer if available and allowed.

Record in the field logbook the methods used to handle, containerize, and dispose of non-hazardous IDW.

6.4 Management of Hazardous IDW

For the purposes of this SOP, hazardous waste means waste meeting the RCRA definition (e.g., waste that exhibits specific hazardous characteristics, is a listed hazardous waste under the statute, or otherwise meets the definition) or waste that contains hazardous constituents regulated under CERCLA (hazardous substances), TSCA (lead, asbestos), CWA, and similar regulations.

The RCRA regulations address the requirements for the handling, storage, transport, disposal, and tracking of hazardous waste. Hazardous IDW containing CERCLA-defined hazardous substances, TSCA-regulated toxic constituents, and other regulated substances similarly must also be handled, stored, transported, disposed, and tracked in accordance with associated regulations.

For hazardous IDW, the following procedures are typically employed:

- Make reasonable efforts to characterize the hazardous IDW. Use available knowledge of historical site activities and existing site processes/raw material/waste stream information, site monitoring, and/or sample analysis data to characterize wastes. Project planning documents will provide the procedures required for sampling/analysis of wastes necessary for waste characterization.
- Containerize hazardous IDW in accordance with regulations.
- Store hazardous IDW in accordance with regulations, with consideration for secure storage and EPA 90-day interim storage rules. For active sites, it may be possible to store hazardous IDW in the facility's designated area.
- Complete any required hazardous waste labels using indelible ink and apply the labels to the waste containers. The labels will typically require generator identification information (the client, never E & E), the date the waste was first accumulated, and the accompanying waste manifest number.
- Complete, or assist others with completion of, the Uniform Hazardous Waste Manifest (see Figure 6-1).
- For sites with an operational treatment/disposal unit (TDU), it may be possible to dispose of hazardous wastes in the on-site TDU, with client approval.
- If off-site disposal of hazardous IDW is required, coordinate with the client to ensure that the hazardous IDW is transported by an approved hazardous waste transporter and disposed of at a permitted treatment, storage, and disposal (TSD) facility, and that the transporter and TSD facility have passed compliance verification. E & E can assist clients with these arrangements but does not take responsibility for hazardous waste transport and ultimate treatment, storage, and disposal. E & E also is not allowed, per E & E legal instructions, to be identified as the hazardous waste generator or to sign hazardous waste shipping manifests. If E & E subcontracts hazardous waste transport and disposal for a project to a qualified subcontractor, E & E still is not identified as the generator, does not sign hazardous waste manifests, and coordinates with the subcontractor and client to ensure that the transporter and TSD facility have passed compliance verification.
- If off-site disposal of hazardous IDW is required, verify that waste container labels comply with EPA and DOT regulations and the requirements of the receiving TSD facility.
- Record in the field logbook the methods used to characterize, handle, containerize, store, dispose of, and track hazardous IDW.

Please print or type. (Form designed for use on elite (12-pitch) typewriter.) Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST

GENERATOR

1. Generator ID Number
2. Page 1 of
3. Emergency Response Phone
4. Manifest Tracking Number

5. Generator's Name and Mailing Address
Generator's Site Address (if different than mailing address)
Generator's Phone:

6. Transporter 1 Company Name — U.S. EPA ID Number

7. Transporter 2 Company Name — U.S. EPA ID Number

8. Designated Facility Name and Site Address — U.S. EPA ID Number
Facility's Phone:

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
	1.					
	2.					
	3.					
	4.					

14. Special Handling Instructions and Additional Information

15. **GENERATOR'S/OFFEROR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.
Generator's/Offeror's Printed/Typed Name — Signature — Month Day Year

INT'L

16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit:
Transporter signature (for exports only): Date leaving U.S.:

TRANSPORTER

17. Transporter Acknowledgment of Receipt of Materials
Transporter 1 Printed/Typed Name — Signature — Month Day Year
Transporter 2 Printed/Typed Name — Signature — Month Day Year

DESIGNATED FACILITY

18. Discrepancy
18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection
Manifest Reference Number:
18b. Alternate Facility (or Generator) — U.S. EPA ID Number
Facility's Phone:
18c. Signature of Alternate Facility (or Generator) — Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1.	2.	3.	4.

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a
Printed/Typed Name — Signature — Month Day Year

EPA Form 8700-22 (Rev. 3-05) Previous editions are obsolete.

DESIGNATED FACILITY TO DESTINATION STATE (IF REQUIRED)

VOID

Figure 6-1 Uniform Hazardous Waste Manifest

In cases where an E & E subcontractor (e.g., driller) produces hazardous IDW, the subcontractor may take responsibility for proper containerization, characterization, labeling, storage, transport, disposal, and tracking of the wastes if authorized under the subcontract. The E & E subcontracting documentation should include relevant subcontractor SOPs for these activities and specify the documentation to be provided to E & E before, during, and after IDW disposal, The E & E project manager or field team leader should verify that subcontractor IDW handling complies with applicable or relevant and appropriate requirements as well as subcontracting requirements. The E & E project manager also should verify that the subcontractor's proposed transporter and TSD facility have passed compliance verification. When a subcontractor is used, the subcontractor and pricing will be identified in the resultant task order.

7 Quality Assurance/Quality Control

The program/project manager will identify personnel for the field team who have knowledge, training, and experience in the handling and management of IDW in accordance with applicable regulations. The field team leader or designee is the lead for IDW handling and will be responsible, with support from other field personnel, for implementing the procedures in this SOP.

The field team leader will verify that IDW handling, storage, transport, disposal, and tracking information is recorded in the field logbook.

The field team leader and project manager will verify that handling and management of both non-hazardous and hazardous waste comply with DOT and other applicable regulations.

8 Health and Safety

IDW associated with explosive, radioactive, mixed (hazardous and radioactive), or pathogenic wastes, and IDW that poses specific toxicity or other safety (e.g., extreme flammability) concerns, are not specifically addressed by this SOP and must be addressed in project planning documents, including the SHASP.

If heavy drums or containers of IDW need to be moved, appropriate mechanical devices such as drum-handling equipment or the equivalent will be used. Prior to moving a drum, it should be visually inspected for labeling to verify the contents, signs of deterioration, signs that it is under pressure (bulging or swelling), or leaking. If the drum shows signs of deterioration, being under pressure, or leaking, it will not be moved until a safe procedure is determined in conjunction with the project manager and site safety officer.

Appropriate PPE will be worn when handling IDW, as specified in the SHASP.

9 Special Project Requirements

Additional project- and site-specific requirements for IDW handling will be included in the project planning documents.

10 References

Scientific, Engineering, Response and Analytical Services (SERAS). 2015. Investigation-Derived Waste Management. SERAS SOP 2049, Rev 0.1. October 5, 2015. Prepared for EPA Emergency Response Team activities. Edison, New Jersey.

United States Environmental Protection Agency (EPA). 1992. Guide to Management of Investigation-Derived Wastes. April 1992. Publication 9345.3-03FS. NTIS: PB92-963353INX. Office of Solid Waste and Emergency Response.

__________. 2014. Management of Investigation Derived Waste. Operating Procedure Number SESDPROC-202-R3. July 3, 2014. EPA Region 4. Athens, Georgia.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

PROCEDURE FOR ROUTINE GPS OPERATION

SOP NUMBER: ENV 3.27 SOP STATUS: Final

REVISION DATE: 6/14/2012 **SCHEDULED REVIEW DATE: 6/14/2013**

Contents

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures utilized by E & E GIS Department and samplers relating to the use of GPS (Global Positioning System) handheld receivers. The GPS is a satellite-based positioning system operated by the U.S. Department of Defense (DOD). A constellation of operational NAVSTAR satellites orbit the earth every 12 hours, providing worldwide, all-weather, 24-hour time and position information. The handheld GPS receivers enable field teams to collect accurate location information in the field associated with sample collection, visual or other observations, field measurements (monitoring) or survey of physical or biological features.

Because GPS instruments and data standards are routinely updated, this SOP incorporates links to E & E and external websites by reference.

This SOP is intended for use by personnel who have knowledge, training and experience in the GPS operation activities being conducted.

2 Definitions and Acronyms

DOP	Dilution of Precision
DQO	Data Quality Objectives
E & E	Ecology and Environment, Inc.
EPA	Environmental Protection Agency
Field	Locations (sites) outside the controlled environment of an office or laboratory.
Field Observation	The qualitative and/or quantitative remarks/statements regarding sensory inputs noted in the field.
Field Measurement	The quantitative determination of physical, chemical, biological, geological or radiological properties of a matrix by measurements made in the field.
Field Sampling	The process of obtaining a representative portion of an environmental matrix suitable for laboratory or field measurement or analysis.
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ID	Identification
PDOP	Positional (3D) Dilution of Precision
POC	Point of Contact
QA	Quality assurance
QC	Quality control
SOP	Standard operating procedure

3 Procedure Summary

GPS handheld receivers are used by E & E personnel to collect data that can be integrated into a GIS. Handheld GPS units serve as mobile platforms for data collection. The data collected can be directly integrated into a GIS and used to store, manage, analyze, map and present a variety of geographical and environmental variables. Additionally, the data collected in the field can serve as a work product that can be delivered to the client.

Several factors need to be considered when selecting the type of GPS receiver for a specific task or application: accuracy requirements, occupation time permitted, and local environment conditions (forest cover, terrain characteristics, etc.) should be taken into account. Depending on one's specific requirements, Survey Grade or Mapping Grade GPS applications can be deployed.

The majority of E & E field work is done with mapping grade GPS units. These types of GPS receivers collect mapping / GIS data with an emphasis on efficiency, rather than accuracy. Data collection time ranges from 1 – 30 seconds per location, depending on local atmospheric and geographic conditions, and number of visible satellites. Coordinate and attribute information are captured simultaneously and stored in a GIS compatible format. The two most commonly used models are the Trimble GeoXH and Trimble Geo6000 Series ©. Both these models utilize the global navigation satellite system (GNSS) to collect positions and deliver sub-meter accuracy. Using an external antenna or post-processing software can increase the accuracy down to the centimeter level. Depending on the project requirements, the GPS unit can be used to either record new data points or navigate to previously recorded locations.

Survey Grade receivers place a higher emphasis on accuracy, but data capture time is significantly increased (45 - 60 minutes per location).

The E & E GIS Department is responsible for the ordering and set-up of GPS units. This is done through the Control Point intranet website (http://gps.ene.com/Default.aspx). The website automates the ordering process, serves as a data management system to track orders and also provides resources for software, proper usage and helpful tips. The majority of GPS units are rented from a preferred vendor, GeoPlane Services (http://www.geoplane.com). The website ordering process is the main communication tool between E & E and GeoPlane (Vendor).

Field personnel access the website to order the rental GPS unit. The GIS Department *GPS Team* (see member list) is notified via e-mail and the GIS project point of contact (POC) is assigned. The POC ensures that the requested background data, imagery, and data collection forms are combined into a mobile software application that is transferred onto the GPS unit. The GPS team is responsible for ensuring the field personnel know how to operate the GPS unit and understand the data collection protocols. When the GPS unit is returned the GPS team retrieves the field data off the GPS unit and returns the rental. The data is post-processed if necessary and then stored on the GIS server for future data mapping and analysis.

Prior to field activity, the program/project manager identifies field personnel; designates a field team leader; and team members responsible for GPS operation in the field activities. GPS operators must have received training in GPS operation. Prior to entering the field, the individual responsible for GPS operation coordinates with the GIS department and project manager to determine how the GPS unit should be set-up. The GPS unit may serve as the primary mechanism to document visual or other observations, field measurements (including instrument/equipment calibrations), or sample collection information associated with location information.

4 Cautions

GPS receivers are sensitive instruments that are used to capture project-specific measurement data. Care should be used in handling and storing the unit. In addition to completing the electronic GPS forms, one team member should record the same pertinent data on hard copy data sheets or logbooks. The level of duplication will depend on the project data quality objectives (DQOs). At the end of each survey day or as soon as possible, the field team will check all data sheets for completeness and accuracy against the electronic data. Field teams back-up electronic data in duplicate locations (e.g. laptop, CDs/DVDs, etc.) until the final files are transferred to E & E secure servers.

5 Equipment and Supplies

The following is a list of GPS equipment we routinely use on projects.

- Geo XH 2008
- Geo XH 6000 Series
- Trimble Yuma (tablet)
- External Zephyr Antenna
- External Patch Antenna
- External Battery Pack (Geo XT and Geo XH 2008 series only)

5.1 Software

ESRI ArcPad is the most commonly used software on mapping grade GPS receivers. ArcPad is a mobile field mapping and data collection software that allows for capturing, editing and displaying geographic information. ArcPad is customizable and compatible with the GIS software used by the E & E GIS Department. Another supported but less used software is Terrasync by Trimble.

6 Procedure

E & E maintains an internal website that provides information on the GPS equipment, training, and operation (http://gps.ene.com/Default.aspx). The website provides a link to current pricing and manufacturer websites and GPS checklists and the site is incorporated into this SOP by reference. An overview of the GPS operation procedure is provided below. In addition, E & E staff should refer to the E & E Field Activity Logbooks SOP DOC 2.1 for guidance on the types of information that should be recorded in addition to the electronic data in the GPS unit and field data collection forms.

6.1 Field Data Collection Preparation

Field personnel should contact the E & E GIS Department for guidance on: GPS equipment, Mobile ArcPad application development and any training that may be required. Table 1 describes the general work flow of Mobile Data Collection preparation methods. The GIS Department can also provide training on the Trimble GPS Receivers, mobile data collection forms, and project-specific data work-flows.

Table 1 GPS Work Flow

Step	Description
1	Determine Field-Schedule and Data Collection Requirements
2	Database Design / Data Collection Strategy
3	Mobile Application Development
4	Mobile Application Quality Assurance and Testing
5	End-User Training
6	Mobile Application Deployment/Data Collection
7	Data Quality Control/Quality Assurance
8	Data Upload and Post-Processing□Repeat Data QA/QC

GIS personnel and field team personnel should review relevant project planning documents, e.g., work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, etc. The data collection strategy and GPS equipment should be chosen to meet project DQOs. The project planning documents should clearly define the requirements for accuracy of the positional data both horizontal and vertical, the datum for reporting, and any metadata standards. Many federal and state agencies have specific GPS standards and GIS data reporting requirements that must be followed. In the absence of project-specific requirements, the project team can consult EPA National Geospatial Data Policy for guidance (http://www.epa.gov/geospatial/docs/National_Geospatial_Data_Policy.pdf).

Most projects for the federal government require metadata describing geospatial data be produced in accordance with the FGDC Content Standard for Digital Geospatial Metadata (http://www.fgdc.gov/metadata/geospatial-metadata-standards).

6.2 GPS Accuracy

The suite of GPS handheld units typically rented by E & E can provide different accuracy as follows:

- Trimble GeoXT Handheld Series: Submeter horizontal accuracy (good for most projects).
- Trimble GeoXH Handheld Series: Subfoot horizontal accuracy (good for most projects) – most often rented GPS receiver
- Trimble Yuma Tablet: a tablet GPS Receiver that allows the user to store a greater amount of data. Runs a full version of Windows. 5 meter horizontal accuracy.
- External Zephyr Antenna: this is an antenna that you can use in conjunction with any of the above listed handheld receivers to improve your accuracy to ~8 inches when using with GeoXT/XH Handheld Series. When using with Yuma, improve accuracy to ~2 meters.

Although manufacture specifications may indicate a level of accuracy, there are numerous factors that can affect the accuracy obtained from the receiver (see Table 2). When highly accurate positional data are required (i.eless than sub-foot) a licensed surveyor should be used.

Table 2 Factors and Ways to Maximize Accuracy

Factor	Description	To Maximize Accuracy
Number of visible satellites	The accuracy of your data increases with the number of satellites being used to calculate the position.	You need at least four satellites to calculate an accurate 3-dimensional position. Trimble data collection software only logs GPS positions when four or more satellites are visible. Tracking more satellites can help to lower DOP values.
Multipath	Multipath is when GPS satellite signals are reflected off nearby objects, such as buildings or cars, causing an erroneous signal to be received by the GPS antenna. This can cause errors of several meters.	To reduce multipath, collect data in an open environment away from large reflective surfaces and with a clear view of the sky. In high multipath environments, record velocity data and use velocity filtering when post-processing the data.
Weak satellite signals	Signal-to-Noise Ratio (SNR) is a measure of the strength of the satellite signal relative to the background noise. Accuracy degrades as the signal strength decreases. Weak signals may be caused by signals coming through vegetation, multipath signals, or low satellite elevation.	Set your GPS application to ignore satellites with a weak SNR. Trimble recommends a minimum SNR setting of 39 dBHz.

Table 2 Factors and Ways to Maximize Accuracy

Factor	Description	To Maximize Accuracy
Poor satellite geometry	Dilution of Precision (DOP) is a measure of the quality of GPS positions, based on the spread (geometry) of the satellites in the sky that are used to compute the positions. DOP can be expressed as a number of separate measurements. HDOP, VDOP, PDOP, and TDOP are respectively Horizontal, Vertical, Positional (3D), and Time Dilution of Precision. When satellites are widely spaced relative to each other, the PDOP value is lower, and position accuracy is greater. If the view of the sky is partially blocked, or if all of the satellites are in one area of the sky, the geometry and DOP may be poor.	Set your GPS application to ignore positions with a poor DOP value. You can choose to filter positions based on PDOP (Positional Dilution of Precision) or HDOP (Horizontal Dilution of Precision). PDOP is a measure of the horizontal and vertical quality of the GPS positions, whereas HDOP is just a measure of the horizontal precision (x and y coordinates). Select HDOP rather than PDOP if you want to ensure positions are accurate horizontally, and when vertical accuracy is less important. Trimble recommends a maximum PDOP setting of 6, or a maximum HDOP setting of 4.
Satellite elevation	When a satellite is low on the horizon, satellite signals must travel farther through the atmosphere. This results in a lower signal strength and delayed reception by the GPS receiver, which can cause errors in calculating the position.	Set the elevation field in your data collection software to ignore satellites that are low in the sky. Trimble recommends a minimum elevation setting of 15°.
Occupation time at a point	Occupation time is the time spent at a point logging GPS positions.	For point features, remain at the feature and log a number of GPS positions to obtain an averaged position. When collecting line and area features, collect them using averaged vertices.

Source: Trimble Getting Started Guide, GeoExplorer 2005 Series V1.10, April 2007

6.3 GPS Data Collection

Field personnel should follow the GPS data checklist and equipment instructions provided on the E & E GPS website. To ensure maximum positional accuracy, the PDOP will be used by the field teams to determine the quality of GPS positions, based on the spread (geometry) of the satellites in the sky that are used to compute the positions. A PDOP setting of ≤ 6, or a HDOP setting of ≤ 4 is recommended; anything larger will likely result in greater positional inaccuracy.

The window of satellite availability is planned through the U.S. Coast Guard and the Department of Homeland Security. Field Team members should consult with Trimble's Planning Software to determine visibility for GPS, GLONASS, IGSO and geostationary satellites. Trimble Planning software is included in the GPSCorrect install, and can be accessed from the GPSCorrect window on the Trimble GPS receiver. Data collection during times of poor PDOP signals should be avoided.

E & E's default Data Collection Settings to ensure accurate GPS data is set as follows:

- A minimum of four visible satellites are available
- Position Dilution of Precision (PDOP) <= 6
- Satellite elevation >= 15° above the horizon
- Acceptable signal-to-noise ratio (SNR) Mask - 39 dBHz.
- 10 GPS points will be collected at each location; the locational average of these points will be captured.

The GIS Department (GPS Team member) will verify that your Trimble Handheld GPS Receiver will be set-up to collect data that meets these requirements. Field personnel should verify that the GPS is functioning properly before collecting data. Other settings may be used based on project-specific requirements.

To provide additional assurance of data accuracy and reproducibility, the field team will capture GPS data points at three known, fixed structures within the project area during each field day. At least one point will be captured *before* the collection of any other data. The other point(s) may be collected when encountered during normal daily field activities. If none are encountered, the field team will drive to the nearest acceptable location to capture the needed points. The locations used each day will be recorded in the field notebook. It is acceptable to use up to two areas (e.g., southwest corner and southeast corner) on one bridge or structure; this will be decided based on field conditions (e.g., traffic, obstructions, etc.) and will be recorded as part of the data identification and in the field notebook.

Field personnel should QA/QC field data on a nightly basis. Although data loss is rare with the newer GPS units, it is advised that a nightly data back-up is performed. E & E field personnel can use the provided ArcPad data entry forms, installed on their laptops, to back-up or edit their data. Use of other GIS programs can result in corrupted data/data loss, and should be avoided. The GPS unit can be used to QA/QC field data and data can be back-up to a secure data memory card.

6.4 Data Transfer and Post-processing

E & E will transfer datasets when the field crews return to the office. The data are usually collected in a local datum. Datasets are differentially corrected using Trimble software and assessed for accuracy. Real-time data collection is utilized when available. This process involves both the field crew and the GIS analysts that are assigned to the project. Data points that may be erroneous or outliers will be checked and may be eliminated from the survey. To ensure spatial data validation, E & E uses high resolution 1-foot ground pixel orthophotography and the field crew notes to check GIS data after transferred to the computer. Daily checks of fixed locations will be used to verify accuracy on a daily basis.

Datasets collected will be mapped and analyzed for both spatial and non-spatial statistics. Generally, GIS analysts will assess the lows and highs of various parameters and distances accompanying the data. Spatial analysis will be carried out using ArcGIS desktop software.

Trimble GPS Receivers collect data in WGS 84 datum. Data will be delivered with coordinates in the original WGS84 coordinate system unless otherwise specific in the project planning documents. ESRI ArcPad software records data in shapefiles that can be referenced to any supported projection coordinate system and datum, and accurately transforms incoming GPS coordinates to the defined projection. The E & E GIS department selects an appropriate coordinate system based on the spatial extent of the survey, and local coordinate system options. Commonly implemented coordinate systems:

- State Plane Coordinate System (SPCS)
- Universal Transverse Mercator (UTM)

7 Quality Assurance/Quality Control

Compliance with/or deviation from the work plan, sampling and analysis plan, quality assurance project plan, or other project or program plans should be recorded together with authorization for any deviations.

Prior to entering the field, the individual responsible for GPS activities should identify daily check points, assess satellite availability and any obstructions that may limit accuracy. If possible, field team should bring a detailed aerial or topographic map with pre-determined coordinates to verify field locations. If it is important to know accuracy of the GPS data to know a standard then it may be necessary to use an established benchmark (see http://www.ngs.noaa.gov/).

The field coordinator will ensure that all paper form based information is scanned or photocopied and maintained with GPS data. The field coordinator will also provide quality assurance/quality control for spatial and attribute consistency performed by the field teams. All hard copy data will be organized into files according to the date collected. The GIS analyst will verify that spatial accuracy meets project requirements and that feature attributes have been entered in fully and accurately. If errors are noticed, measures will be taken to reconcile them with field team assistance as soon as possible. After QA checks are complete, the files will be saved for GIS processing.

8 Special Project Requirements

EPA Great Lakes National Program Office (GLNPO) has a specific data collection for GPS data. Locational Data Checklist and Metadata Recording Form and GPS Daily Check form. These forms will be completed for projects associated with Great Lakes based on the current version available. The forms will be included with the project planning documents.

9 References

The following list sources of sources information on GPS data collection.

http://gis.ny.gov/coordinationprogram/workgroups/wg_1/related/standards/documents/GPS_Guidelines_FINAL.pdf

http://www.state.nj.us/dep/gis/gpsoutstand.html

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

BOREHOLE INSTALLATION AND SUBSURFACE SOIL SAMPLING METHODS

SOP NUMBER: GEO 4.7

REVISION DATE: 5/25/2012 **SCHEDULED REVIEW DATE: 5/26/2017**

Contents

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures utilized by E & E for collection of unconsolidated and consolidated subsurface samples from boreholes using a subcontract driller. Most subsurface investigations require the drilling of boreholes for one or more purposes: collection of soil samples for lithologic logging and laboratory testing; lithologic and hydrogeologic characterization using borehole geophysical logging; and installation of piezometers or monitoring wells. Drilling methods are selected based on availability and cost; suitability for the type of geologic materials at a site (unconsolidated or consolidated); and potential effects on sample integrity (influence by drilling fluids and potential for cross-contamination between aquifers). Site-specific drilling methods and sampling procedures also vary depending on the data quality objectives (DQOs) identified in program/project planning documents.

Procedures for collecting soil samples for volatile organic compound (VOC) analyses are presented in the E & E VOC Soil and Sediment Sampling SOP ENV 25.

Procedures for collecting surface and shallow subsurface soil sampling SOP are presented in the E & E Borehole Installation Methods SOP ENV 3.13.

Procedures for sample handling are defined in E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16. Site-specific sample handling procedures are dependent on the project DQOs.

Procedures for equipment decontamination are defined in E & E Sampling Equipment Decontamination SOP ENV 3.15. Site-specific equipment decontamination procedures are dependent on the project DQOs.

This is intended for use by personnel who have knowledge, training and experience in the field soil sampling activities being conducted.

2 Definitions and Acronyms

DQO	Data Quality Objective
E & E	Ecology and Environment, Inc.
HSA	hollow-stem auger
SHASP	Site Specific Health and Safety Plan
SOP	Standard Operating Procedure
VOC	Volatile Organic Compound

3 Procedure Summary

A wide variety of drilling methods have been developed that could be suitable for one or more of the purposes described above. Table 1 summarizes information on drilling methods.

Table 1 Summary Information on Drilling Methods

Drill Method	Casing/ Open Hole	Can Drill Fluids Affect Groundwater Quality?	Core Samples?
Hollow-Stem Auger	Open Hole	No	Possible
Direct-Push/Geoprobe®	Either	No	Yes
Open-Hole Rotary Methods			
Direct Air Rotary with Bit	Open Hole	Yes	Possible
Direct Air Rotary with Downhole Hammer	Open Hole	Yes	Possible
Direct Mud Rotary	Open Hole	Yes	Possible
Reverse Rotary (no casing)	Open Hole	Yes	Possible
Cable Tool	Either	No	Possible
Rotary Drill-Through Methods			
Rotary Casing Driver	Casing	Yes	Possible
Dual Rotary Advancement	Casing	Yes	Possible
Other Methods			
Reverse Dual Wall Rotary	Casing	Yes	Possible
Reverse Dual Wall Percussion	Casing	Yes	Possible
Hydraulic Percussion	Casing	Yes	Possible
Downhole Casing Advancers	Casing	Yes	Possible
Jet Percussion	Casing	Possible	Possible
Jetting	Open Hole	Possible	No
Solid-Stem Auger	Open Hole	No	Possible
Bucket Auger	Open Hole	No	Possible
Rotary Diamond	Open Hole	Possible	Yes
Directional Drilling	Either[a]	Possible	Possible[b]
Sonic Drilling	Either	Possible	Yes
Driven Wells	Either	No	No
Cone Penetration	Open Hole	No	Possible[c]

Notes:
[a] EC rig uses casing advancement; other methods may involve open-hole advancement.
[b] Sampling with a device resembling a split spoon may be possible with some directional rigs.
[c] Geoprobe has developed a core sampler for use with a cone penetration testing rig.

Subsurface soil samples are collected from boreholes for chemical and physical analysis and to aid in the definition and tracking of contaminants in the soil. The subsurface soil samples may be either composite or discrete, and either disturbed or undisturbed. The type of sample to be collected depends on the drilling technique and the purpose of the investigation.

4 Cautions

Cautions associated with borehole installation include decontamination procedures, depth control, and health and safety associated with heavy equipment use. All equipment that is brought on site must be clean prior to arrival and all downhole equipment must be decontaminated prior to drilling each boring location. This is an important factor to ensure that off-site contaminants are not introduced to the soils (and groundwater) being collected and that contaminants encountered at one site location are not spread throughout the site.

Depth control is also an important factor to ensure that exact soil horizons, formations, and zones of contamination identified during sampling are accurately documented and will allow for accurate placement of well materials. The oversight geologist should be familiar with the drilling methodology and independently verify measurements on a regular basis. This will identify any discrepancies between the oversight geologist and the drill rig operator.

As with any heavy equipment operation, proper personal protective equipment is essential. At a minimum, Level-D protection will be required for all drilling operations.

5 Equipment and Supplies

The equipment and supplies required for field work depend on the program/project DQOs. The following is a general list of equipment and supplies. A detailed list of equipment and supplies should be prepared based on the project planning documents. In general, the use of dedicated or disposal equipment is preferred but equipment may be re-used after thorough decontamination between sample locations (refer to E & E Sampling Equipment Decontamination SOP ENV 3.15).

- Stainless-steel or Teflon™ spoons, trowels, or scoops. Other construction material may be acceptable depending upon the program/project planning documents and DQOs
- Soil-coring equipment or augers acceptable depending upon the program/project planning documents and DQOs
- Sampler such as thin-walled tube sampler (e.g., shelby tube sampler), split-spoon sampler, continuous soil core sampler (e.g. Laskey), continuous-flight auger, or direct push soil corer (e.g., Macro-Core®).
- Stainless-steel mixing bowls. Other bowl construction material may be acceptable depending upon the program/project planning documents and DQOs
- Spade(s) and/or shovel(s)
- Liners and/or catchers for augers or core samplers as specified in the project planning documents
- Pipe cutter(s), stainless steel knives(s), or power saw to cut liners
- Survey stakes or flags to mark locations
- Ancillary equipment and supplies, e.g., meter stick or tape measure, aluminum foil, plastic sheeting, disposable gloves.

Supporting equipment and supplies also may be required to address the following:

- Field logbooks and supplies (Refer to project planning documents and the E & E Field Activity Logbooks SOP DOC 2.1 for details)
- Decontamination equipment and supplies (Refer to project planning documents and E & E Sampling Equipment Decontamination SOP ENV 3.15for details)
- Sample containers, preservatives, and shipping equipment and supplies (Refer to project planning documents and the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for details)
- Waste handling supplies (Refer to project planning documents and E & E Handling Investigation-Derived Wastes SOP ENV 3.26 for details)

6 Procedure

The most accurate method for obtaining information on the characteristics of unconsolidated deposits is to collect representative samples of the soil at measured depths and at intervals that will provide a complete lithologic profile of the soils. E & E staff will use the following procedures for completing borehole installation and subsurface soil sampling:

- Review relevant project planning documents, e.g., work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, etc.
- Select the sampling procedure(s) that meet project DQOs.
- Refer to the E & E Field Activity Logbooks SOP DOC 2.1 for guidance on the types of information that should be recorded for each sample.
- Refer to the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for guidance on how samples should be labeled, packaged, and shipped.

6.1 Subsurface Soil Sampling Methods

6.1.1 Disturbed and Undisturbed Overburden Samples

Soil samples from unconsolidated deposits can be collected as disturbed or undisturbed soil samples. Disturbed soil samples are produced by the action of the hollow-stem auger (HSA) and are called drill cuttings. The components of an HSA are shown in Figure 1. Disturbed samples are not representative of the formations penetrated because of the possible sorting and grinding of the cuttings while being carried to the surface. In general, disturbed samples do not contain detailed lithologic information, and the depth that the soil is encountered is less precise.

Mildly disturbed to relatively undisturbed soil samples are collected in a variety of sampling devices, including the split spoon or split-barrel sampler (see Figure 2), and the continuous soil core sampler (see Figure 3). Sonic drilling also provides relatively undisturbed samples. Undisturbed soil samples are collected using the thin-walled tube sampler (see Figure 4).

The collection of undisturbed samples ensures the preservation of detailed lithologic information (such as the degree of consolidation, sorting, bedding, etc.) and a more accurate estimation of sample depth.

6.1.2 Composite and Discrete Overburden Samples

Composite samples are prepared from aliquots of discrete samples. They are useful for obtaining a representative sample from a subsurface interval for analytical purposes. However, composite samples are inadequate for lithologic purposes.

Discrete samples are obtained from a specific depth and are useful when detailed analytical information about the overburden soils is required. Analysis of discrete overburden soil samples provides the more accurate information on the depth of contamination than composite samples.

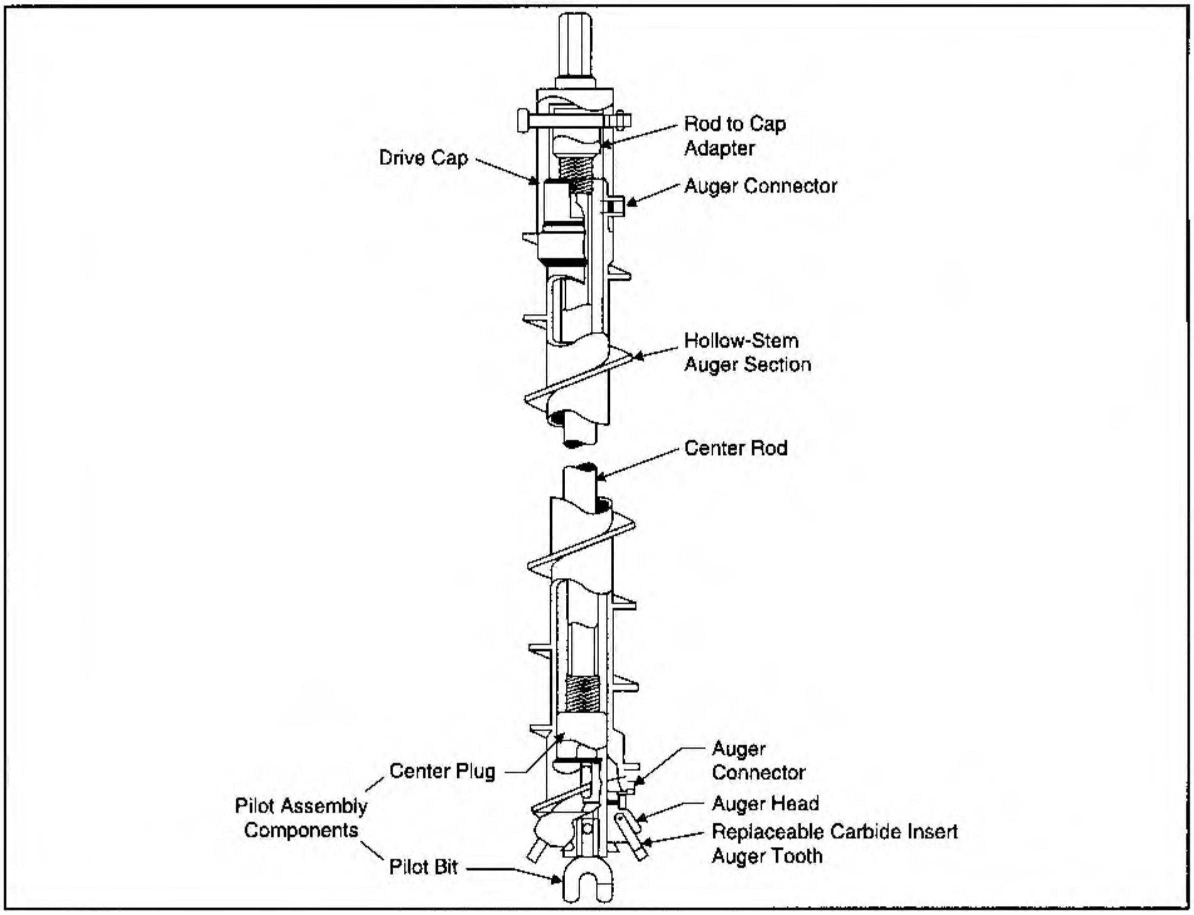

Figure 1 Typical Components of a Hollow-Stem Auger

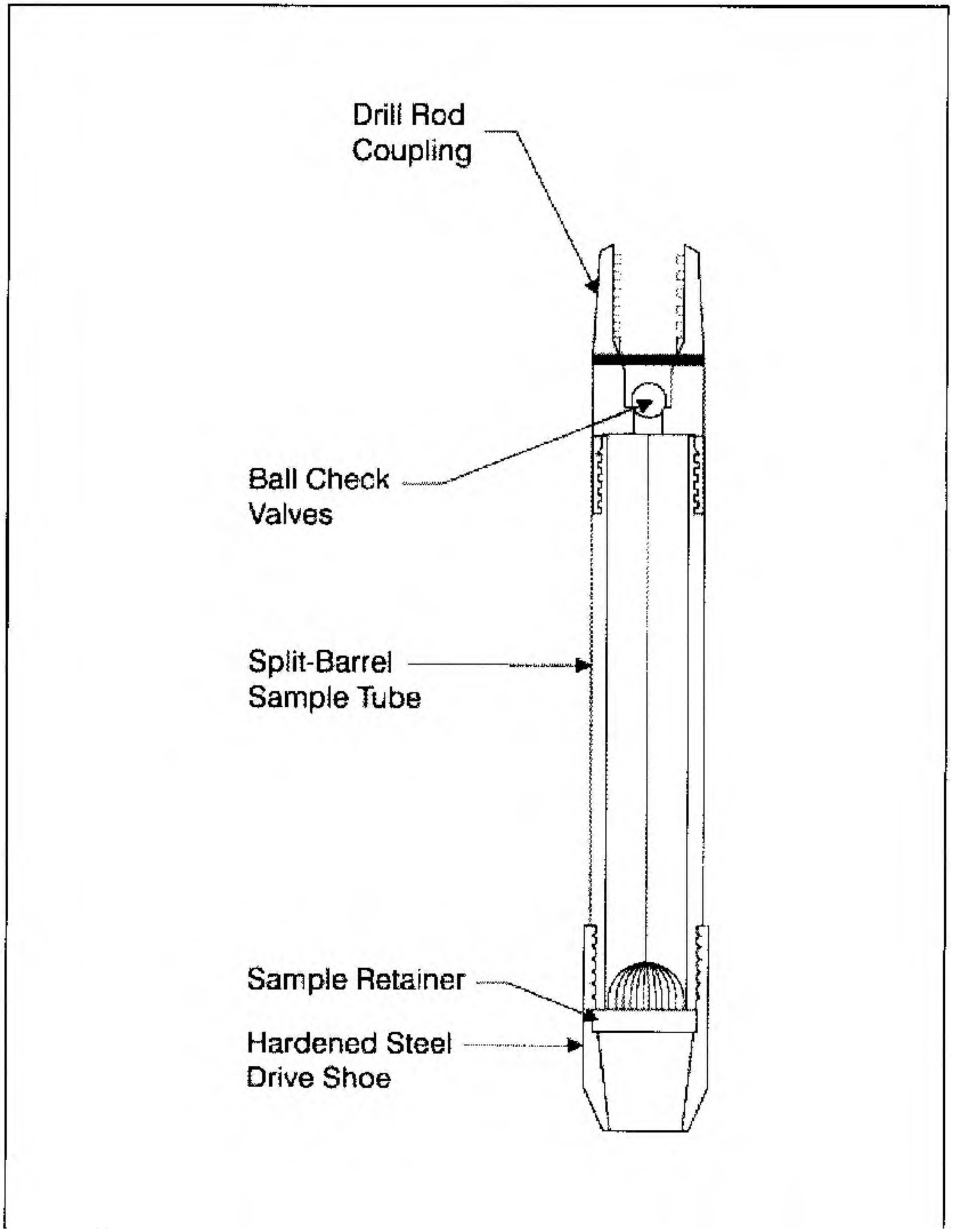

Figure 2 Split-Spoon or Split-Barrel Sampler

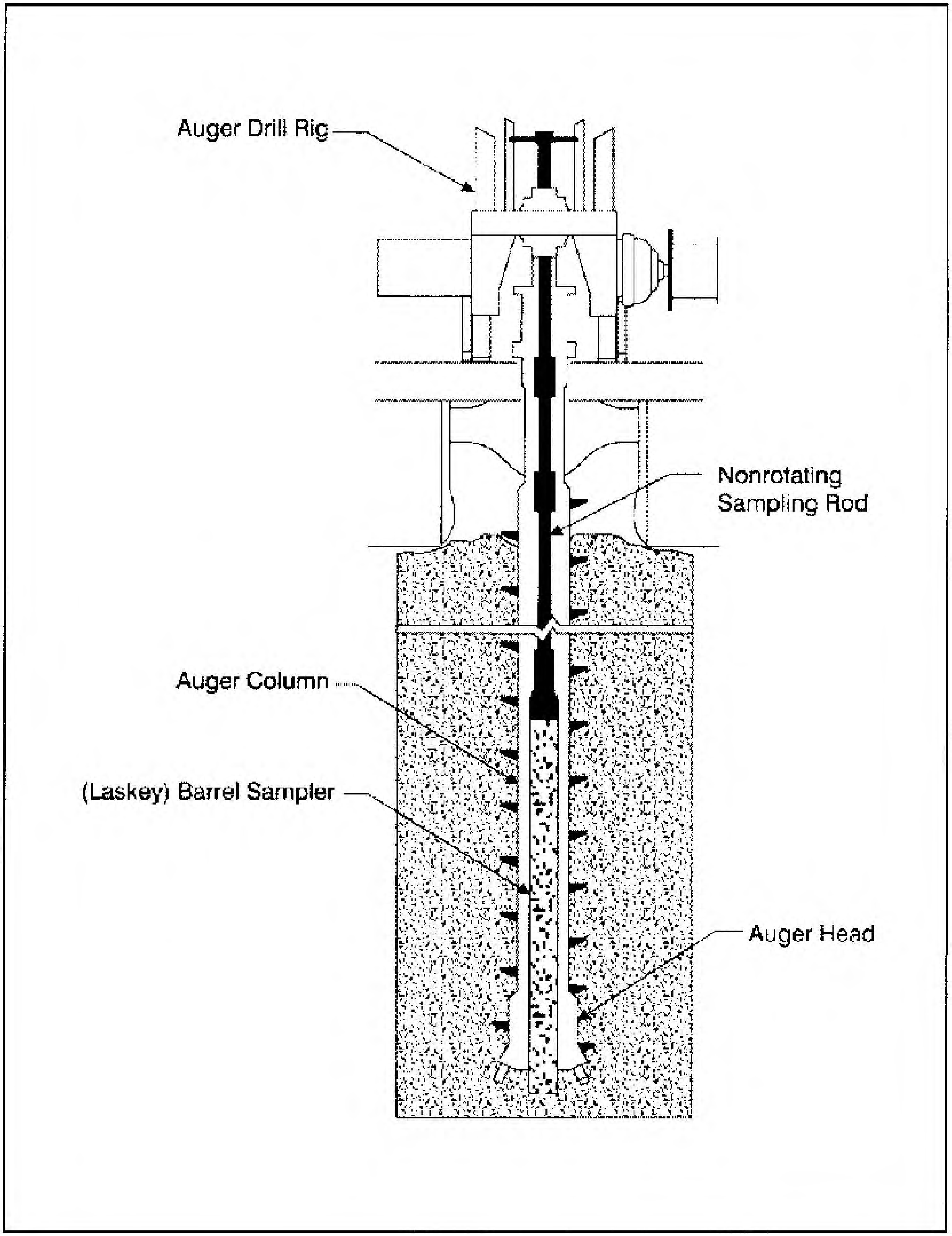

Figure 3 Continuous Sampling Tube System (Laskey)

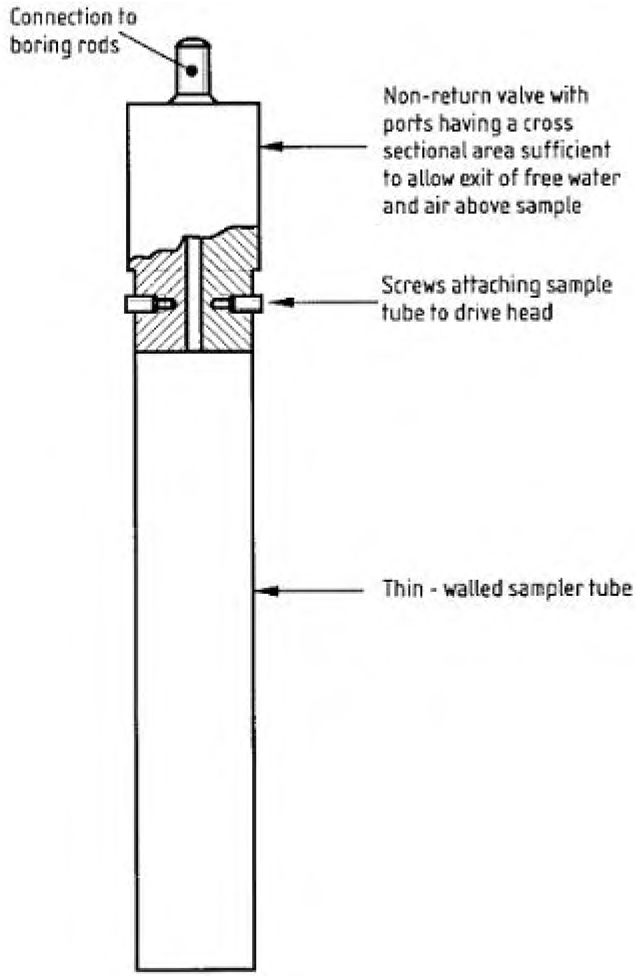

Figure 4 Shelby Tube Sampler

6.1.3 Environmental Sample Collection

Samples for environmental laboratory analysis can be collected from sampling devices described above and in Section 6.2.

1. Samplers should be decontaminated or dedicated for collection of environmental samples.
2. Samplers should be in a perpendicular position on the sample material.
3. Sampling methods should attempt to minimize compression of the sample.
4. Record the length of the tube used to penetrate the material being sampled and the number of blows required to obtain this depth.
5. Once the sample is collected record all length of sample and estimate sample recovery and compression. Project planning documents may indicate acceptability criteria for samples recovery and sample collection. The geologist will need to determine based on site conditions if poor recovery is due to sampling equipment or the geologic formation. The goal is obtain a sample for environmental analysis that is representative of subsurface soil at a specified depth interval and meet the project DQOs. If samples don't meet the DQOs then determine a course of action with the project manager.

6. Soil samples should be collection as soon as possible following extraction of the sampler.
    - Place sampler or liner on clean surface
    - Carefully remove any end caps and/or catchers
    - Evaluate record core length, geologic information, monitoring data, and any visual observations.
    - For transverse sectioning of liners, beginning at the soil surface, measure and mark the sample sections on the outside of the liner
        - Cut the liner with a manual pipe cutter or core liner and core with a decontaminated saw blade into marked sections.
        - Extrude the soil from the cut segments of the liner. If necessary use a plunger cover with aluminum foil to aid in extruding the core.
        - Empty the core segment into a stainless steel bowl (or other type as specified in the project planning documents).
        - Record observations of the soil types.
        - Immediately collect volatile organic analyte and sulfide samples.
    - For longitudinal sectioning of cores, open the split spoon or use a knife to cut the liner and expose the upper half of the soil cylinder.
        - Beginning at the soil surface, measure and mark the sample sections using a tape measure set aside the core.
        - Record observations of the soil types.
        - Immediately collect volatile organic analyte and sulfide samples.
        - Scope the core segment into a stainless steel bowl (or other type as specified in the project planning documents).
    - If multiple core segments are necessary to collect adequate sample volume, they should all be combined in the bowl prior to homogenization
    - Homogenize the sample as thoroughly as possible
    - Transfer sample aliquots to appropriate sample containers and preserve as required in the project planning documents.
7. Return unused soil to the boring or containerize as specific in the project planning documents,
8. Follow proper procedures for sample handling and transportation to the laboratory for analysis.

6.1.4 Geotechnical Sample Collection

Some sampling devices also may be used to collect information for geotechnical analysis such as soil density. Geotechnical sampling should strictly follow standards for sampling based on the type of test performed. This information should be documented in the project planning documents. Detailed procedures are not included here because standards are routinely updated and only the most current standard should be used. Spilt spoon sampling work should be performed in accordance with American Society for Testing and Materials (ASTM) ASTM

D1586 - 11 *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*. If thin-wall tube sampling is used for soil collection, then follow ASTM D1587 - 08 *Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes.*

6.2 Borehole Installation

6.2.1 Inspection and Cleaning of Sampling Equipment

Proper cleaning of the drill rig, downhole equipment, and sampling equipment prior to arriving at the site and between drilling locations is necessary to minimize the potential introduction of contaminants into soil and groundwater samples. A rig should not be allowed to enter a site if the rig appears to be dirty (other than road dirt) from previous use at another site. While operating on site, the drill rig should be checked repeatedly for oil and hydraulic fluid leaks. These precautions are essential to ensure that trace contaminants from the drilling process are not introduced to the samples.

Before drilling begins at a site, and after each boring is completed, all the down-the-hole drill equipment, the rig, and other equipment (as necessary) should be steam cleaned, or cleaned using high-pressure hot water, and rinsed with pressurized potable water to minimize cross contamination. Special attention should be given to the threaded sections of the casings and drill rods. Additional cleaning may be necessary during the drilling of individual holes to minimize the carrying of contaminated materials from shallow to deeper strata by contaminated equipment (e.g., decontamination of split spoon samplers as associated drill rods).

Equipment with porous surfaces, such as rope, cloth hoses, and wooden blocks or tool handles cannot be thoroughly decontaminated. These should be disposed of properly at appropriate intervals. These intervals may be the duration of drilling at the site, between individual wells, or between stages of drilling a single well, depending upon characteristics of the tools, site contamination, and other considerations.

Cleaned equipment should not be handled with soiled gloves. Surgical gloves, new clean cotton work gloves, or other appropriate gloves should be used and disposed of when even slightly soiled. The use of new painted drill bits and tools should be avoided since paint chips can bias soil and groundwater samples.

Upon completion of drilling activities at a particular site, all drilling equipment should be steam cleaned or cleaned using high-pressure hot water to ensure that no contamination is transported off site.

6.2.2 Hollow-Stem Auger Drilling

An HSA column simultaneously rotates and axially advances using a mechanically or hydraulically powered drill rig. The hollow stem of the auger allows use of various methods for continuous or intermittent sampling of subsurface soils. Riser and screen for monitoring wells can be placed in the hollow stem when the desired depth has been reached, and filter pack and grouting emplaced as the auger is gradually withdrawn from the hole. Use of different diameter augers allows use of casings to isolate near-surface contamination and continuation of drilling with a smaller-diameter auger. HSA flights are manufactured in 5-foot lengths and have various inside diameters ranging from 2.25 inches to 10.25 inches.

If a split-barrel soil sampler is used to collect unconsolidated soil samples, a center plug of the same diameter as the HSAs and a section of drilling rod are placed inside the lead flight. The HSAs are advanced through the unconsolidated deposits to the first sampling interval, and the center plug is then removed from the HSAs. A precleaned split-barrel soil sampler is attached to the end of the drilling rod and lowered into the HSAs. A safety hammer is attached to the top of the drilling rod, and the split-barrel soil sampler driven into the undisturbed soil to a depth of 2 feet. The split-barrel soil sampler is retrieved and opened to remove the soil sample. The center plug is replaced in the HSAs, and another flight of HSAs is attached to the top of the flight already in the ground. The process is repeated until bedrock is encountered or the project depth is reached.

A continuous soil core sampler (i.e., Laskey) is used to collect 5-foot continuous soil core samples while the HSAs are turning. The Laskey soil sampler is used instead of a center plug in 4.25-inch HSAs, and the head of the sampler leads the HSAs by 2 to 6 inches. At the completion of a 5-foot run of HSAs, the Laskey soil sampler is recovered and opened in a manner similar to a split-barrel sampler. Following sample collection and decontamination of the Laskey soil sampler, the sampler is replaced inside the HSAs, and another flight of HSAs is attached to the top of the flight already in the ground.

A Shelby tube sampler is used to collect undisturbed overburden soil samples in a manner similar to a split-barrel soil sampler. Once the HSAs have reached the top of the interval to be sampled, the drilling rods holding the center plug are withdrawn from the HSAs, the Shelby tube is attached to the end of the drilling rod, and the Shelby tube is lowered into the HSAs. The Shelby tube is pushed out the bottom of the HSAs to the prescribed depth, and the tube is retrieved. The Shelby tube is not opened in the field, but is shipped to the laboratory. The process is repeated until bedrock is encountered or the project depth is reached.

6.2.3 Direct-Push/Geoprobe

Installation of boreholes using direct-push/Geoprobe® methods utilizes a hydraulically powered machine to drive rods into the subsurface with both static (downward push) and percussive (hammer) force. Rod widths generally vary from 1.25 inches to 4.25 inches in diameter. This method can be used for continuous or discrete soil sampling in unconsolidated formations only. This method of borehole installation is effective for achieving depths up to 60 feet below ground surface or less, although newer more powerful machines have recently been constructed that have achieved depths in excess of 200 feet below ground surface in certain formations (e.g., 8000 Series Geoprobe®).

There are two soil sampling methods commonly used, macro-core and dual tube. The macro-core sampler does not incorporate the use of casing and utilizes a center rod to hold the core barrel tip in place until the desired depth is reached. The center rod is removed at the desired depth so that soils are allowed to enter the core barrel while it is further driven into the subsurface. The entire assembly is removed to retrieve the soil core and the borehole may collapse at this time. Because the borehole can collapse in between sampling, there are some concerns with slough and cross contamination using this method. A plastic sleeve lines the length of the macro-core barrel to contain the soils and is used to remove the soils. The plastic sleeve should be replaced with a new sleeve for each soil core. This method can be used for continuous or discrete sampling and typically uses a 2.25-inch core barrel and yields a 1.25-inch soil core (other sizes available).

Dual-tube soil sampling utilizes one set of rods that are advanced as an outer casing. A set of inner rods are used to hold a 4- or 5-foot plastic sleeve in the tip of the casing/rod. After each 4- or 5-foot increment, the plastic sleeve is removed using the inner rods and replaced with a new liner before advancing further. Borehole advancement only continues when the soil core barrel is placed back into the borehole and mated with the leading rod of the casing. This method is generally used for continuous soil sampling although it can be utilized for discrete sampling using a center rod. The typical diameter of tooling using this set up is 4.25-inche casing with a 3-inch soil core. Because the casing remains in place, this method is effective for use in saturated formations and areas where cross contamination is of concern. Given the greater diameter of the tooling, this method typically is more limited in depths of penetration (Geoprobe® 2006).

6.2.4 Direct Mud Rotary

Direct mud rotary bore hole drilling is advanced through rapid rotation of a drill bit (Tri-cone) mounted upon the end of drill rods. The bit cuts and breaks the material at the bottom of the hole into small pieces (cuttings). The cuttings are removed by pumping drilling fluid (water, or water mixed with bentonite or other fluid enhancers) down through the drill rods and bit and up the annulus between the bore hole and the drill rods. The fluid is referred to as drilling mud. Drilling mud is recirculated through the use of a “mud tub” where cuttings are accumulated and drilling mud is pumped back down the drilling rods. The drilling fluid also serves to cool the drill bit and stabilize the bore-hole walls, to prevent the flow of fluids between the bore hole and surrounding earth materials, and to reduce cross contamination between aquifers. Direct mud rotary drilling offers a number of advantages; it is a fast and efficient means of drilling. Efficient rigs can produce several hundred feet of hole per day. The direct mud rotary method can reach to several thousand feet in depth and create hole diameters to greater than 48 inches. The method is adaptable to a wide range of geologic conditions. Only exceptionally large, poorly stabilized boulders, or karst (cavernous) conditions are unsuited for direct mud rotary drilling. Direct mud rotary rigs are widely available throughout the United States. Sediment sampling is broadly supported in direct mud rotary drilling: standard split-barrel and thin-wall sampling are available in poorly lithified materials while a broad range of coring apparatus’ are supported for consolidated rock. Hydrologic conditions have little effect upon direct mud rotary drilling; operations are usually unhindered by the presence of ground water. Direct mud rotary drilling readily supports the telescoping of casings to successively smaller sizes to isolate drilled intervals and to protect lower geologic units from contamination by previously drilled, contaminated upper sediments.

The use of direct mud rotary drilling requires careful management of drilling fluids to prevent the buildup of drilling mud (mud cake) in permeable intervals, which can impact the quality of water samples collected from the monitoring well and inhibit flow to the well. A pH neutral bentonite should be used to prevent interference with water quality samples. Additionally, care has to be taken to ensure that organic compounds sometimes added to drilling fluids do not interfere with chemical analysis of water samples. To prevent this, drilling muds will only contain chemically inert substances and the use of petroleum products for fittings and pipe joints will be prohibited. Substitutes for petroleum grease such as vegetable-based oil and lubricants will be utilized.

Direct mud rotary drilling may sometimes be the best available alternative, especially for deep wells or wells completed into well lithified rocks. When direct mud rotary methods are used, hole diameters should be 3 to 5 inches larger than the outer diameter of the well casings to allow effective placement of filter and sealing materials. Two-inch diameter monitoring wells should therefore be installed within 5.5-inch diameter or larger holes.

6.2.5 Direct Air Rotary and Downhole Hammer

The basic rig setup for air rotary with a tri-cone or roller-cone bit is similar to direct mud rotary, except that the circulation medium is air rather than water or mud. Compressed air is circulated down through the drill rods to cool the bit and carry cuttings up the hole to the surface. A cyclone separator slows the air velocity and allows the cuttings to fall into a container. A down-the-hole hammer, which operates with a pounding action as it rotates, replaces the roller-cone bit.

6.2.6 Sonic Drilling

The sonic drill rig is similar to other drilling rigs in that it is a machine attached to a frame mounted on some type of vehicle. Sonic drilling is the application of high frequency vibration used in conjunction with down pressure and rotation to advance drilling tools through subsurface formations (see Figure 5). The use of high frequency vibration through the drilling tools causes the formation materials to vibrate at their natural frequencies allowing the drilling tool (casing) to advance by fracturing, shearing, or displacing formation material. Most sonic drilling is utilized for drilling in unconsolidated material. However, sonic drilling can also be used for drilling and sampling of rock formations.

During drilling, unconsolidated samples are collected using a sample (or core) barrel. Core barrels are either solid tubes or split barrels of various diameters and lengths generally sized to match the inside diameter of the drill casing being utilized. Typical core barrels are 10 to 20 feet in length and casing sizes range from 0.5 inches to 12 inches, although 4- to 6-inch casing is typical. The core barrel is fitted with a drill bit/cutting shoe, and the sampler is placed within the outer casing material and attached to the rig by drilling rods. As the borehole is advanced, formation material is collected within the core barrel.

Following the sampling run (typically 10 to 20 feet), the core barrel is extracted from the well casing. Formation material is then extracted from the core barrel. Typically, sample material is extracted into a plastic sleeve, which is separated into convenient lengths for logging. The process of sonic drilling and sample collection will cause the sample to be distorted due to vibration, but generally will be intact. In the case of rock drilling, the vibration may create mechanical fractures that can affect the structural analysis for permeability and thereby not reflect the true *in-situ* condition.

The advantages to using sonic drilling technology include reducing the amount of drill cutting generated, providing rapid formation penetration, and the recovery of a continuous core sample.

6.3 Borehole Abandonment

Borehole abandonment is necessary to eliminate potential physical hazards, prevent groundwater contamination, conserve aquifer yield and hydrostatic head, and prevent intermixing of surface water and subsurface water. After the necessary unconsolidated soil samples or consolidated core samples have been collected from the borehole, the HSAs are removed from the borehole and the HSA flights cleaned. A cement/bentonite grout should be tremied into the borehole to the surface. The grout should consist of potable water, bentonite powder, and Type I Portland cement, with 94 pounds of cement and 5 pounds of bentonite per 6.5 gallons of water.

Always determine whether there are applicable regulatory or programmatic specific borehole abandonment procedures or reporting requirements.

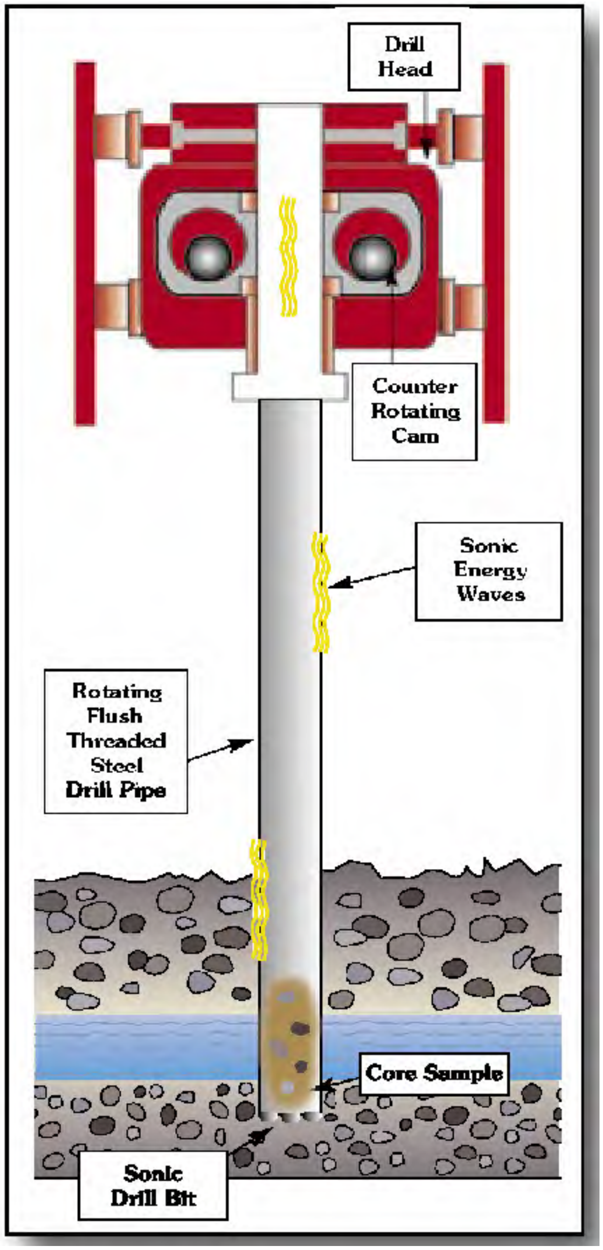

Figure 5 Typical Sonic Drilling Components

7 Quality Assurance/Quality Control

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, SHASP, *et al*) should be reviewed by field personnel to identify sampling procedure(s) that will most likely provide surface and shallow subsurface soil samples that meet project DQOs.

The program/project manager should identify personnel for the field team who have knowledge, training and experience in the borehole installation and subsurface soil sampling activities being conducted typically trained geologist. The geologist should document all borehole sampling and lithological information in E & E's geotechnical logbook. All project personnel, if necessary, can complete ancillary procedures, e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal.

The lead geologist should prepare a detailed equipment checklist before entering the field and verify that sufficient and appropriate equipment and supplies are taken into the field.

Quality assurance/quality control samples (e.g., co-located samples) are collected according to the site quality assurance project plan. Field duplicates are collected from one location and treated as separate samples. Field duplicates are typically collected after the samples have been homogenized. Collocated samples are generally collected from nearby locations and are collected as completely separate samples. Rinsate blanks may be necessary to evaluate the effectiveness of field decontamination procedures (see E & E SOP Env 3.15).

In cases where multiple hand-collected scoop, auger or core samples are required to generate an adequate sample volume, homogenization is important. Field personnel should collect sample aliquots only after mixing has produced soil with textural and color homogeneity.

At sites with known or suspected contamination, samples should be collected moving from least to most contaminated areas.

8 Health and Safety

Prior to entering the field, all field personnel formally acknowledge that they have read and understand the project specific health and safety plan.

Augers and soil core sampling apparatus are inherently dangerous pieces of heavy equipment which a high “pinch” potential. Care should be taken at all times when handling such equipment, not just during sample collection.

Prior to any subsurface work, verify that underground utilities have been located and marked.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be entered in this section and included with the project planning documents.

10 References

See E & E SOP Env 3.13 for additional sources of technical information on soil sampling.

Geoprobe®. 2006. Geoprobe® DT 325 Dual Tube Sampling System, Technical Bulletin NO. MK 3138, revised 1/2011.

END OF SOP

Title:	**GEOLOGIC LOGGING**
Category:	GEO 4.8
Revised:	March 1998

STANDARD OPERATING PROCEDURE

GEOLOGIC LOGGING

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TITLE:	**GEOLOGIC LOGGING**		
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1. Introduction

Geologic logging involves keeping detailed records during the drilling of boreholes, the installation of monitoring wells, and the excavation of test pits, and entering the geologic descriptions of the soil and rock samples recovered on a standardized form. E & E has adapted a standardized geotechnical logbook (see DOC 2.4 in E & E's Standard Operating Procedures [SOPs]) that contains items deemed important to record when installing monitoring wells, piezometers, and/or soil borings. This document discusses general procedures for completing geologic logs.

2. Drilling Logs

2.1 Basic Documentation

When drilling boreholes, the project geologist should maintain a log that describes each borehole. The E & E Geotechnical Logbook contains records for boreholes. The following basic information should be entered on the heading of each drilling log sheet (see Figure 1):

- Borehole/well number;
- Project name;
- Site location;
- Dates and times that drilling was started and completed;
- Drilling company;
- E & E geologist's name;
- Drill rig type used to drill the borehole;
- Drilling method(s) used to drill the borehole;

DRILLING LOG FOR ____________________

Project Name ____________________

Site Location ____________________

____

Date Started/Finished ____________________

Drilling Company ____________________

Driller's Name ____________________

Geologist's Name ____________________

Geologist's Signature ____________________

Rig Type(s) ____________________

Drilling Method(s) ____________________

Bit Size(s) __________ Auger Size(s) __________

Auger/Split Spoon Refusal ____________________

Total Depth of Borehole is ____________________

Total Depth of Corehole is ____________________

Water Level (TOIC)		
Date	Time	Level (Feet)

Well Location Sketch

N

Depth (Feet)	Sample Number	Blows on Sampler	Soil Components CL SI S GR	Rock Pile	Penetration Times	Run Number	Core Recovery	RQD	Fracture Sketch	HNu/OVA (ppm)	Comments
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											

Figure 1 Drilling Log

- Bit and auger size(s);
- Depth of auger/split barrel sampler refusal;
- Total depth of borehole;
- Total depth of corehole (if applicable);
- Water level at time of completion measured from top of inside casing (TOIC); and
- A well location sketch.

2.2 Technical Information

During the drilling of a borehole, specific technical information about the unconsolidated material and rock encountered should be recorded on the drilling log sheet. The following minimum technical information should be recorded:

- Depth that sample was collected or encountered;
- Sample number assigned (if applicable);
- The number of blow counts required to drive the split barrel sampler 2 feet at 6-inch intervals (see Table 1);
- Description of soil components (see Figure 2);
- Description of rock profile (see Figure 3);
- Rock qualitative designation (RQD) (see Figure 4);
- Rock penetration time;
- Core run number (if applicable) and percent recovery; and
- Organic vapor readings in the sample.

Table 1 Standard Penetration Test for Soil Density

N-Blows/Feet	Relative Density
Cohesionless Soils	
0 - 4	Very loose
4 - 10	Loose
10 - 30	Medium
30 - 50	Dense
50	Very dense
Cohesive Soils	
2	Very soft
2 - 4	Soft
4 - 8	Medium
8 - 15	Stiff
15 - 30	Very stiff
30	Hard

3. Soil Classification

Soils should be described using the Unified Soil Classification System (USCS) in the narrative lithologic description section of Figure 5. Figure 6 is a summary of the American Society for Testing and Materials (ASTM) criteria for describing soils. Soil descriptions should be concise, stressing major constituents and characteristics, and should be given in a consistent order and format. The following order is recommended by the ASTM:

1. Soil name. The basic name of the predominant constituent and a single-word modifier indicating the major subordinate constituent.

2. Gradation or Plasticity. Granular soils (i.e., sands or gravels) should be described as well-graded, poorly-graded, uniform, or gap-graded, depending on the gradation of the minus 3-inch fraction. Cohesive soils (i.e., silts and clays) should be described as nonplastic, slightly plastic, moderately plastic, or highly plastic, depending on results of the manual evaluation for plasticity.

3. Particle size distribution. An estimate of the percentage and grain-size range of each subordinate constituent of the soil. This description may also include a description of angularity (see Figure 7).

4. Color. The basic color of the soil.

SOIL AND SEDIMENT CLASSIFICATION

GRAIN-SIZE SCALE (Modified Wentworth Scale)

phi	mm	inches	U.S. Standard Sieve Series	Grade Name		
-12	4096	161.30				
				very large		
-11	2048	80.60				
				large		
-10	1024	40.30			Boulders	
				medium		
-9	512	20.20				
				small		
-8	256	10.10				
				large		
-7	128	5.00			Cobbles	
				small		GRAVEL
-6	64	2.52	63.0 mm			
				very coarse		
-5	32	1.26	31.5 mm			
				coarse		
-4	16	0.63	16 .0 mm			
				medium	Pebbles	
-3	8	0.32	8.0 mm			
				fine		
-2	4	0.16	No. 5			
				very fine		
-1	2	0.08	No. 10			
				very coarse		
0	1	0.04	No. 18			
				coarse	Sand	SAND
+1	0.500		No. 35			
				medium		
+2	0 250		No 60			
				fine		
+3	0.125		No. 120			
				very fine		
+4	0.062		No. 230			
				coarse		
+5	0.031				Silt	
				medium		
+6	0.016					
				fine		MUD
+7	0.008					
				very fine		
+8	0.004					
				coarse		
+9	0.002					
				medium		
+10	0 001					
				fine		
+11	0.0005					CLAY SIZE
				very fine		
+12	0.00025					

PROPORTIONS USED IN DESCRIBING SOILS

Trace - Particles are present but estimated to be less than 5%
Few - 5 to 10%
Little - 15 to 25%
Some - 30 to 45%
Mostly - 50 to 100%

I.e.: Sand with a trace of silt = 95% Sand, < 5% Silt

(When sampling gravelly soils with a standard split spoon, the true percentage of gravel is often not recovered due to relatively small sample diameter.)

Soil Density from Standard Penetration Test (ASTM D1586)

Granular Soils	Cohesive Soils
0 - 10: Loose	0 - 4: Soft
10 - 30: Medium Dense	4 - 8 : Medium Stiff
30 - 50 Dense	8 - 15 . Stiff
Over 50: Very Dense	15 - 30 : Very Stiff

CLASSIFICATION CHART(United Soil Classification System)

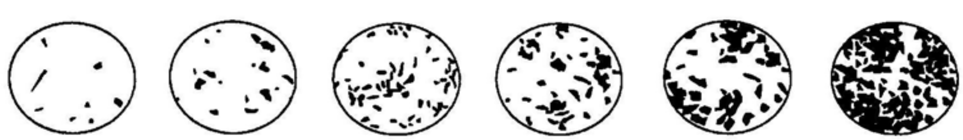
MAJOR DIVISIONS			Symbols	TYPICAL NAMES
Coarse Grained Soils	(More than 1/2 of soil > no 200 sieve size)	GRAVELS (More than 1/2 of coarse fraction > No. 4 sieve size)	GW	Well-graded gravels or gravel-sand mixtures,little or no fines
			GP	Poorly graded gravels or gravel-sand mixtures little or no fines
			GM	Silty gravels, gravel-sand-silt mixture
			CC	Clayey gravels, gravel-sand-clay mixtures
		SANDS (More than 1/2 of coarse fraction < No. 4 sieve size)	SW	Well-graded sands or gravelly sands, little or no fines
			SP	Poorly graded sands or gravelly sands, little or no fines
			SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand clay mixtures
Fine Grained Soils	(More than 1/2 of soil < no 200 sieve size)	SILTS AND CLAYS LL< 50	ML	Inorganic silts, and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays, of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic clays of low plasticity
		SILTS AND CLAYS LL> 50	MH	Inorganic silts, micaceous or diatamaceous, fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils

Figure 2 USCS Soil Classification Chart

ROCK DESCRIPTIVE TERMS

Term		Defining Characteristics	
Hardness	Soft	Scratched by fingernail	
	Moderately Hard	Scratched easily by penknife	
	Hard	Difficult to scratch with a penknife	
	Very Hard	Cannot be scratched by penknife	
Weathering	Unweathered	Rock is unstained. May be fractured, but discontinuities are not stained.	
	Slighty	Rock is unstained. Discontinuities show some staining on the surfaces of rocks, but discoloration does not penetrate rock mass.	
	Moderate	Discontinuity surfaces are stained. Discoloration may extend into rock along discontinuity surfaces.	
	High	Individual rock fragments are thoroughly stained and may be crumbly.	
	Severe	Rock appears to consist of gravel-sized fragments in a "soil" matrix. Individual fragments are thoroughly discolored and can be broken with fingers.	
Bedding Planes	Laminated	< .04 in.	< 1 mm
	Parting	.04 in. - .24 in.	1mm - 6mm
	Banded	.24 in. - 1in.	6 mm - 3 cm
	Thin	1 in. - 4 in.	3 cm - 9.1 cm
	Medium	4 in. - 12 in.	9.1 cm - 30.5 cm
	Thick	12 in.- 36 in.	30.5 cm - 1m
	Massive	> 36 in.	> 1 m
Joints and Fracture Spacing	Very tight	< 2 in.	< 5.1 cm
	Tight	2 in. - 1ft.	5.1 - 30.5 cm
	Moderately tight	1ft. - 3 ft.	30.5 cm - 91.4 cm
	Wide	3 ft. - 10 ft.	91.4 cm - 3 M
	Very wide	> 10 ft.	> 3 M
Voids	Porous	Smaller than a pinhead. Their presence is indicated by the degree of absorbency.	
	Pitted	Pinhead size to a 1/4 inch. If only thin walls separate the individual pits, the core may be described as honeycombed.	
	Vug	1/4 inch to the diameter of the core. The upper limit will vary with core size.	
	Cavity	Larger than the diameter of the core.	

Rock Particle Percent Composition Estimation



1% 5% 10% 15% 25% 50%

Figure 3 Rock Descriptive Terms

ROCK QUALITY DESIGNATION (RQD) AND FRACTURE FREQUENCY

Core borings are a useful means of obtaining information about the quality of rock mass. The recoverable core indicates the character of the intact rock and the number and character of the natural discontinuities.

Another quantitative index that has proved useful in logging NX core is a rock quality designation (RQD) developed by Deere (1963). The RQD is a modified core recovery percentage in which all the pieces of sound NX core over 4 inches long are counted as recovery. The length of the core run is the distance to the nearest tenth of a foot from the corrected depth of the hole at the end of the previous run to the corrected depth of the hole at the end of subject run. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. The RQD is a more general measure of the core quality than the fracture frequency. Core loss, weathered and soft zones, as well as fractures, are accounted for in this determination. The RQD provides a preliminary estimate of the variation of the in situ rock mass properties from the properties of the "sound" portion of the rock core. Thus, a general estimate of the behavior of the rock mass can be made. An RQD approaching 100 percent denotes an excellent quality rock mass with properties similar to that of an intact specimen. RQD values ranging from 0 to 50 percent are indicative of a poor quality rock mass having a small fraction of the strength and stiffness measured for an intact specimen.

RQD (Rock Quality Designation)

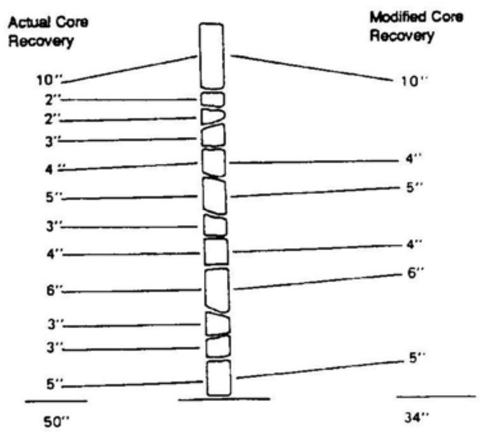
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

An example of determining the RQD from a core run of 60 inches measured from corrected depth to corrected depth is given in Diagram 1. For this particular case, the core recovery was 50 inches and the modified core recovery was 34 inches. This yields an RQD of 57 percent, classifying the rock mass in the fair category.

Problems arise in the use of RQD for determining the in situ rock mass quality. The RQD evaluates fractures in the core caused by the drilling process, as well as in natural fractures previously existing in the rock mass. For example, when the core hole penetrates a fault zone or a joint, additional breaks may form that, although not natural fractures, are caused by natural planes of weakness existing in the rock mass. These fresh breaks occur during drilling and handling of the core and are not related to the quality of the rock mass. The skill of the driller will affect the amount of breakage and the core loss that occurs. Poor drilling techniques will "penalize" the rock by lowering its apparent quality. It is difficult to distinguish between drilling breaks and those natural and incipient fractures that reflect the quality of the rock mass. In certain instances, it may be advisable to include all fractures when estimating RQD. Obviously, some judgement is involved in core logging.

Another problem with the use of the RQD index is that the determinations are not sensative to the tightness of the individual joints, whereas in some instances, the in situ deformation modulus may be strongly affected by the average joint opening.

RQD OF A SINGLE CORE RUN *

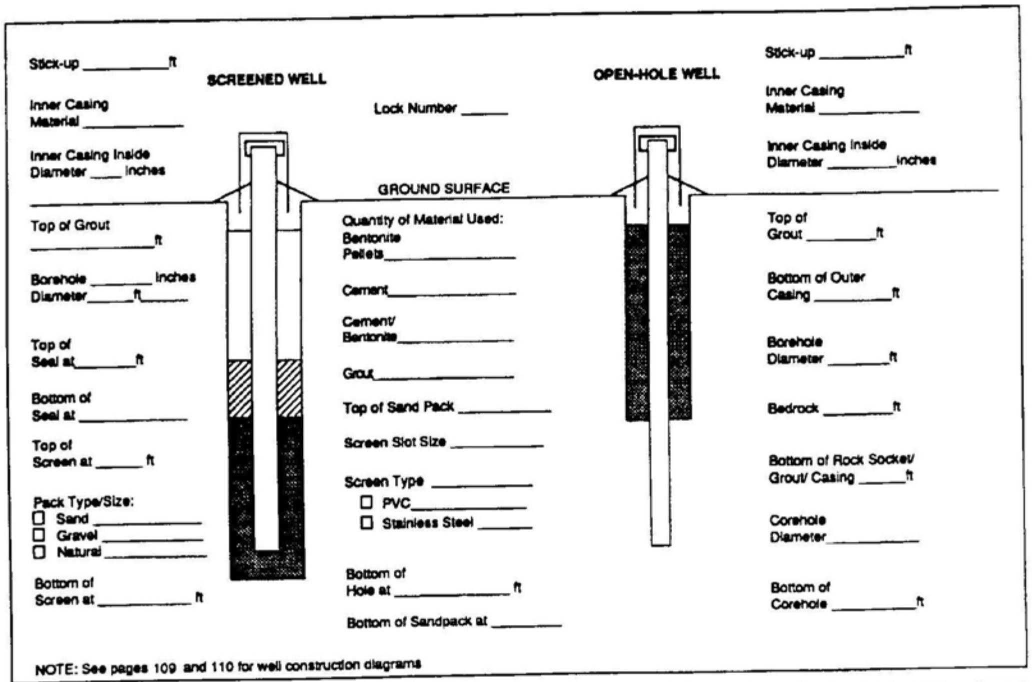


Core Run 60"
(Corrected depth to corrected depth)

$\frac{34"}{60"}$ x 100% = 57% = Fair

* Typical calculation of RQD of a single core run. Note that the run is calculated from corrected depth to corrected depth.

Figure 4 Rock Qualitative Designation (RQD)



Stick-up ______ ft
Inner Casing Material ______
Inner Casing Inside Diameter ____ inches
Top of Grout ______ ft
Borehole ______ inches
Diameter ______ ft ______
Top of Seal at ______ ft
Bottom of Seal at ______
Top of Screen at ______ ft
Pack Type/Size:
☐ Sand ______
☐ Gravel ______
☐ Natural ______
Bottom of Screen at ______ ft

SCREENED WELL

Lock Number ______

GROUND SURFACE

Quantity of Material Used:
Bentonite Pellets ______
Cement ______
Cement/ Bentonite ______
Grout ______
Top of Sand Pack ______
Screen Slot Size ______
Screen Type ______
☐ PVC ______
☐ Stainless Steel ______
Bottom of Hole at ______ ft
Bottom of Sandpack at ______

OPEN-HOLE WELL

Stick-up ______ ft
Inner Casing Material ______
Inner Casing Inside Diameter ______ inches
Top of Grout ______ ft
Bottom of Outer Casing ______ ft
Borehole Diameter ______ ft
Bedrock ______ ft
Bottom of Rock Socket/ Grout/ Casing ______ ft
Corehole Diameter ______
Bottom of Corehole ______ ft

NOTE: See pages 109 and 110 for well construction diagrams

Depth-ft.	NARRATIVE LITHOLOGIC DESCRIPTION	Moisture Content: Dry	Moist	Wet
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

Figure 5 Narrative Lithologic Description

ASTM CRITERIA FOR DESCRIBING SOIL

Criteria for Describing Angularity of Coarse-Grained Particles

Description	Criteria
Angular	Particles have sharp edges and relatively plane side with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved side and no edges

Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit . The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and shard surface

Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varing material or color with layers at least 6 mm thick; note thickness.
Laminated	Alternating layers of varying materials or color with the layers less than 6 mm thick; note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout.

Figure 6 ASTM Criteria For Describing Soil

CRITERIA FOR DESCRIBING SOIL (Cont.)

Criteria for Describing the Reaction with HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

Criteria for Describing Consistency

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will indent soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

Criteria for Describing Particle Shape

The particle shape shall be described as follows where length, width, and thickness refer to greatest, intermediate, and least dimensions of a particle, respectively (see page 104).

Flat	Particles with width/thickness ratio > 3
Elongated	Particles with length/width ratio > 3
Flat and Elongated	Particles meet criteria for both flat and elongated

Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8 inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Figure 6 ASTM Criteria for Describing Soil (cont.)

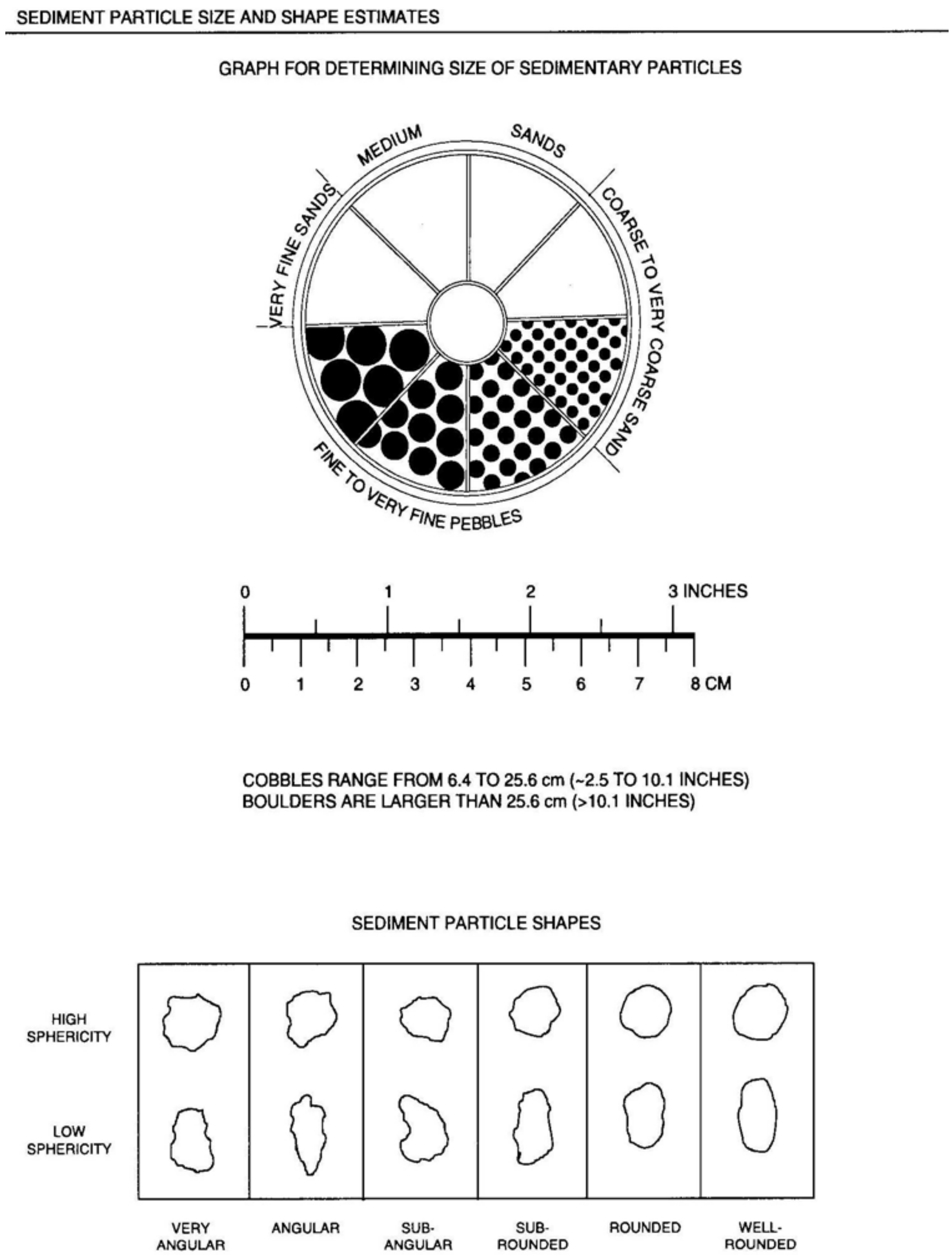


Figure 7 Sediment Particle Size and Shape Estimates

5. Moisture content. The amount of soil moisture (dry, moist, or wet).

6. Relative density or consistency. An estimate of density of a granular soil or consistency of a cohesive soil, usually based on the standard penetration test results (see Table 1).

7. Soil Structure or Mineralogy. Description of discontinuities, inclusions, and structures. Includes joints, fissures, and slickensides.

4. Core Logging

4.1 Handling of Core

After the core has been recovered from the corehole and the core barrel has been opened, the core should be placed in a core box. The top of the core should be placed at the back left corner of the core box, and the remaining core placed to the right of the preceding section (see Figure 8). The core box should be filled in this manner, moving to the front sections of the core box. The beginning of each run should be marked on the core and also noted with a marked wooden block.

4.2 Rock Description

Each stratigraphic unit in the core shall be logged. A line marking the depth of the top and the bottom of the unit shall be drawn horizontally. In classifying the rock, the geologist should avoid being too technical, as the information presented must be used by numerous people with widely divergent backgrounds.

The classification and description of each unit should be given in the following order, as applicable:

1. Unit designation (Miami oolite, Clayton Formation, Chattanooga shale);

2. Rock type;

3. Hardness;

4. Degree of weathering;

5. Texture;

6. Structure;

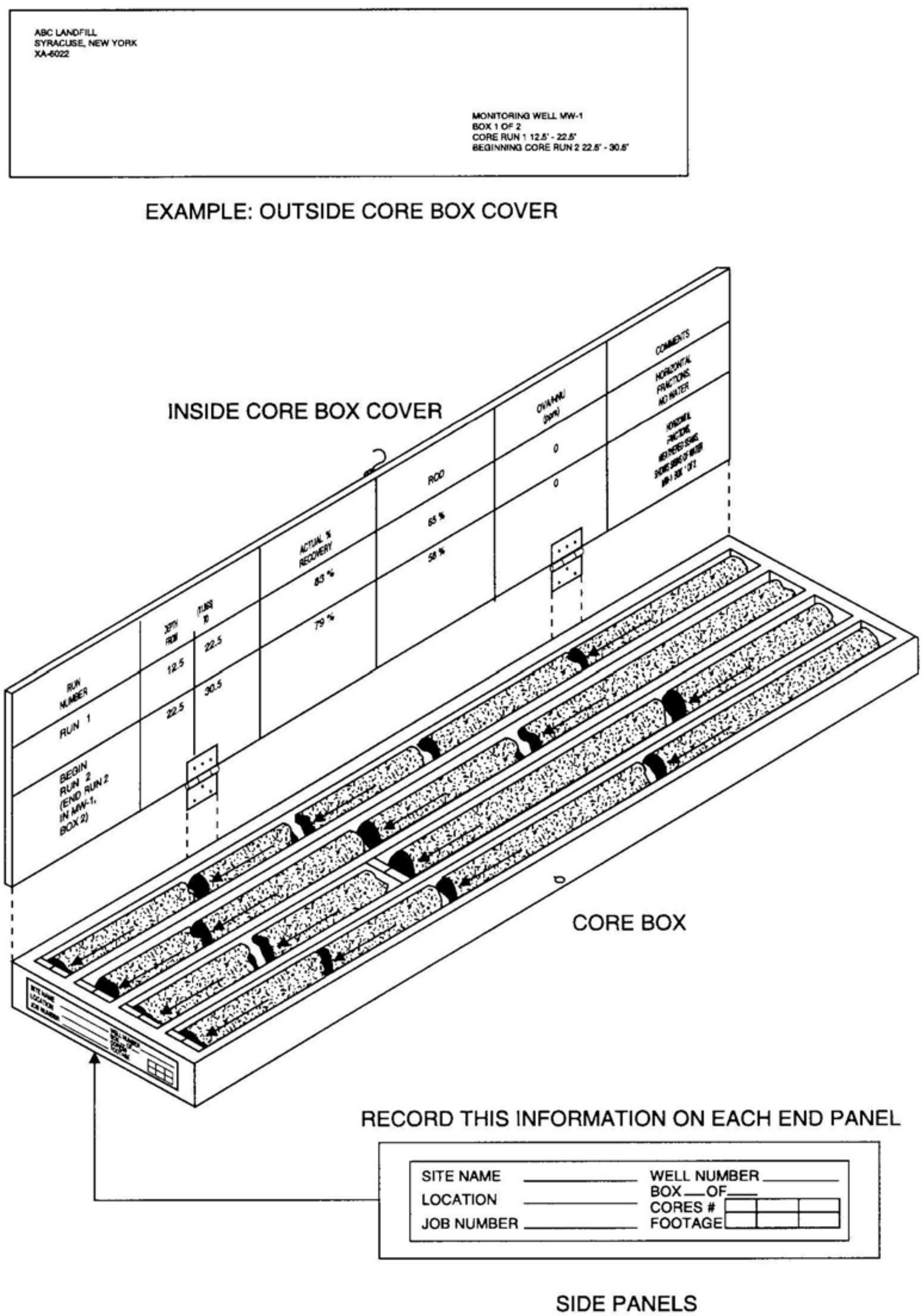


Figure 8 Core Box

7. Color;

8. Solution and void conditions;

9. Swelling properties;

10. Slaking properties; and

11. Additional description, such as mineralization, size, and spacing shale seams, etc.

Variations from the general description of the unit and features not included in the general description shall be indicated by brackets and lines to show the depth and the interval in the core where the feature exists. These variations and features shall be identified by terms that will adequately describe the feature or variation so as to delineate it from the unit. These may be zones or seams of different color, texture, etc., from that of the unit as a whole, such as staining; variations in texture; shale seams, gypsum seams, chert nodules, calcite masses, etc.; mineralized zones; vuggy zones, joints, fractures; open and/or stained bedding planes; faults, shear zones, gouge; cavities' thickness, open or filled, nature of filling, etc.; or any core left in the bottom of the hole after the final pull.

Rock Type and Lithology

1. Rock will be classified according to the following 24 types:

   - Sandstone
   - Conglomerate
   - Coal
   - Compaction Shale
   - Cemented Shale
   - Indurated Clay
   - Limestone
   - Chalk
   - Gneiss
   - Schist

- Graywacke
- Quartzite
- Dolomite
- Marble
- Soapstone and Serpentine
- Slate
- Granite
- Diorite
- Gabbro
- Rhyolite
- Andesite
- Basalt
- Tuff or Tuff Breccia
- Agglomerate or Flow Breccia

2. Lithologic characteristics should be included to differentiate rocks of the same classification. These adjectives should be simple and easily understood, such as shaly, sandy, dolomitic, etc. Inclusions, nodules, and concretions should also be noted here.

3. It is important to maintain a simple but accurate rock classification. The rock type and lithologic characteristics are essentially used to differentiate the rock units encountered.

Hardness

The terms for hardness, as outlined below, were modified to include the use of a rock hammer.

1. **Very soft** or plastic - can be deformed by hand (has a rock-like character but can be broken easily by hand).

2. **Soft** - can be scratched with a fingernail (cannot be crumbled between fingers but can be easily pitted with light blows of a geology hammer).

3. **Moderately hard** - can be scratched easily with a knife; cannot be scratched with a fingernail (can be pitted with moderate blows of a geology hammer).

4. **Hard** - difficult to scratch with a knife (cannot be pitted with a geology hammer but can be chipped with moderate blows of the hammer).

5. **Very hard** - cannot be scratched with a knife (chips can be broken off only with heavy blows of the geology hammer).

Weathering

The degree and depth of weathering is very important and should be accurately detailed in the general description and clearly indicated on the drill log.

1. **Unweathered** - no evidence of any mechanical or chemical alteration.

2. **Slightly weathered** - superficial discoloration, alteration, and/or discoloration along discontinuities; less than 10% of the rock volume is altered; strength is essentially unaffected.

3. **Moderately weathered** - discoloration is evident; surface is pitted and altered, with alterations penetrating well below rock surfaces; 10% to 50% of the rock is altered; strength is noticeably less than unweathered rock.

4. **Highly weathered** - entire section is discolored; alteration is greater than 50%; some areas of slightly weathered rock are present; some minerals are leached away; retains only a fraction of its original strength (wet strength is usually lower than dry strength).

5. **Decomposed** - saprolite; rock is essentially reduced to a soil with a relic rock texture; can be molded or crumbled by hand.

Texture

Texture is used to denote the size of the grains or crystals comprising the rock, as opposed to the arrangement of the grains or crystals, which is considered a structure.

1. **Aphanitic** - grain diameter less than 0.004 inch (0.1 mm); individual grains or crystals are too small to be seen with the naked eye.

2. **Fine-grained, finely crystalline** - grain diameter between 0.004 inch (0.1 mm) and 0.003 (1 mm); grains or crystals can be seen with the naked eye.

3. **Medium-grained, crystalline** - grain diameters between 0.003 foot (1 mm) and 0.0175 foot (5 mm).

4. **Coarse-grained, coarsely crystalline** - grain diameter greater than 0.0175 foot (5 mm).

Structure

The structural character of the rock shall be described in terms of grain or crystal alignment, bedding, and discontinuities, as applicable. The terms may be used singularly or paired.

1. **Foliation and/or lineation** - give approximate dip uniformity, degree of distinctiveness, banding, etc.

2. **Joints:**
   a. Type - bedding, cleavage, foliation, extension, etc.
   b. Degree of openness - tight or open.
   c. Surface or joint plane characteristics - smooth, rough, undulating.
   d. Weathering - degree, staining.
   e. Frequency - see (4).

3. **Fractures, shears, gouge:**
   a. Nature - single plane or zone. (Note thickness.)
   b. Character of materials in plane or zone.
   c. Slickensides.

4. **Frequency:**
   a. Intact - spacing greater than 6 feet (2 m).
   b. Slightly jointed (fractured) - spacing 3 feet (1 m) to 6 feet (2 m).
   c. Moderately jointed (fractured) - spacing 1 foot (0.3 m) to 3 feet (1 m).
   d. Highly jointed (fractured) - spacing 0.3 foot (9.1 cm) to 1 foot (0.3 m).
   e. Intensely jointed (fractured) - spacing less than 0.3 foot (9.1 cm).

5. **Bedding** is used to describe the average thickness of the individual beds within recognized unit, and the terms thick, medium, or thin should not be applied to the individual beds. "Parting" and "band" are used to describe single stratum as outlined below:
   a. Massive - over 3 feet thick (1 m).
   b. Thick - 1 foot (30.5 cm) to 3 feet (1 m) thick.
   c. Medium - 0.3 foot (9.1 cm) to 1 foot (30.5 cm) thick.
   d. Thin - 0.1 foot (3.0 cm) to 0.3 foot (9.1 cm) thick.

e. Band - 0.02 foot (6 mm) to 0.1 foot (3.0 cm) thick, described to the nearest 0.01 foot.
f. Parting - less than 0.02 foot (6 mm).
g. Paper-thin parting.

The terms and descriptions for the structure of the rock are to be used to describe the character of the rock units recognized and are not to be used as a substitute for describing individual discontinuities. Except for areas where the rock is intensely fractured or jointed, each discontinuity should be described on the log as to position, dip, staining, weathering, breccia, gouge, etc.

Color is often valuable in correlating or differentiating samples, but can be misleading or uninformative. The color of a sample should represent the sample in terms of basic hues (i.e., red, blue, gray, black), supplemented with modifying hues as required (i.e., bluish gray, mottled brown). The core should be surface wet when describing the color; if it is dry, the log should indicate "dry color." Subjective colors, such as buff or maroon, should not be used. Specific color charts, such as the Mumsel Color Chart or the Color Index in the Colorado School of Mines, Quarterly, Volume 50, No. 1, are useful in describing color of samples. When such a chart or index is used, it should be noted on the log in the remarks column.

Solution and Void Conditions shall be described in detail, as these features can affect the strength of the rock and can indicate potential seepage paths through the rock. When cavities are detected by drill action, the depth to top and bottom of the cavity should be determined by measuring the stick-up of the drill tools when the cavity is first encountered and again at the bottom, as it is very difficult to reconstruct cavities from the core alone. Filling material, when present and recovered, should be described in detail opposite the cavity. When no material is recovered from the area of the cavity, the inspector should note the probable conditions of the cavity as determined from observing the drilling action and the color of the drill fluid. If the drill action indicated material was present (i.e., slow rod drop, no loss of drill water, noticeable change in color of water return), it should be noted on the log that the cavity was probably filled and the materials should be described as best as possible from the cuttings or traces left on the core. If drill action indicates the cavity was open (i.e., no resistance to the drill tools, loss of drill fluid), this should be noted on the drill log. Partially filled cavities should also be noted. All of these observations require close observation of the drill action and water return by both the inspector and the driller; accurate measurement of stick-ups; and detailed inspection of the core. When possible, filling material should be wrapped in foil if left in the core box. If the material is to be tested or examined in the lab, it should be sealed in a jar with proper labels and a spacer, with a note showing the disposition of the material should be placed in the core box at the point from which the material was taken. Terms to describe voids encountered shall be as follows:

1. **Porous** - voids less than 0.003 foot (1 mm) in diameter.

2. **Pitted** - voids 0.03 foot (1 mm) to 0.02 foot (6 mm) in diameter.

3. **Vug** - voids 0.02 foot (6 mm) to the diameter of the core.

4. **Cavity** - voids greater than diameter of the core.

4.3 Core Labeling

The top of the core should be shown on each piece of core with an arrow written in a black, waterproof marker. The arrow will indicate which end of the core is nearer the ground surface. Other core markings may include locations of mechanical breaks and drilling footages.

4.4 Core Box Labeling

Each core box should be labeled as follows:

- On the top left corner of the outer core box, the project name, site location (city and state), and project number should be written.

- On the lower right corner of the outer core box, the corehole number (e.g., MW1, BH2), core box number (e.g., 1 of 2, 2 of 2), and the interval of the core run contained in the core box should be written.

- The side panels should be marked as indicated in Figure 8.

- The inside of the core box cover should be marked as indicated in Figure 8.

4.5 Core Storage

It is important to use proper-sized (HQ or NQ) wooden core boxes for rock core storage. After labeling the box and before closing the box for final storage or shipment, wooden spacers should be inserted into each compartment that contains rock core. This will prevent lateral movement of the cores, which could damage the rock material during handling.

After properly logging, labelling, and packing the cores, the core boxes should be stored in a dry location, preferably off of the floor on a pallet. The boxes can be stacked to a reasonable height so as not to be unstable, with end labelling facing out.

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STANDARD OPERATING PROCEDURE

GEOPROBE OPERATION

SOP NUMBER: GEO 4.12

REVISION DATE: 4/16/2013 **SCHEDULED REVIEW DATE: 4/16/2018**

Contents

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1 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures utilized by Ecology and Environment, Inc. (E & E) for operation of the E & E owned Geoprobe® and collection of samples using the probe. Additionally, this document can be used as a primer for E & E personnel that are performing field oversight of direct-push operations being conducted by others.

There are a variety of direct-push machines currently being manufactured and the array of subsurface sampling tools grows each year. The two most common types of direct-push machines are vehicle-mounted (E & E's Geoprobe® is mounted in a pickup truck) and stand-alone track-driven units that are typically trailered to a site, then moved around the site on their "tracks" via a hand-held, radio-operated remote control box. Other less commonly used types of direct-push units include those that mount to tractors, skid-steers (Bobcats), all-terrain vehicles, and even hand carts. Additionally, because several equipment companies are now manufacturing their own rigs that use technology similar to that used by Geoprobe Systems, Inc., the generic term "direct-push" is commonly used in place of "Geoprobe". Because this SOP applies to all direct-push machines, the term Geoprobe® will be used only when referring specifically to the Geoprobe® brand.

This document provides basic information on the operation and application of the various direct-push models for subsurface investigations. This document is NOT intended to be used as an operator's guide or a training manual for the operation of Geoprobes® or other direct-push machines. Operating instructions for specific machines should be obtained from the manufacturer prior to use. Additionally, hands-on training with an experienced operator is a prerequisite to unsupervised operation of direct-push machinery and associated tooling. Field procedures and limitations of direct-push technologies are discussed. This document is meant to be used in conjunction with manufacturer's instructions and other E & E standard operating procedures for field operations. It incorporates safety precautions that should be followed when planning a subsurface investigation.

Procedures for sample handling are defined in E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16. Site-specific sample handling procedures are dependent on the project data quality objectives (DQO).

Procedures for equipment decontamination are defined in E & E Sampling Equipment Decontamination SOP ENV 3.15. Site-specific equipment decontamination procedures are dependent on the project DQOs.

This is intended for use by personnel who have knowledge, training and experience in the direct-push operation and sampling activities being conducted.

1.1 Objectives

Direct-push machines can be used to collect subsurface samples to determine the presence and/or extent of contaminants in soil gas, groundwater, and soils with minimum disturbance to the ground surface. Direct-push machines are hydraulically powered units which may be mounted in a van, truck, small 4-wheel drive all-terrain vehicle or can be self-propelled. They are capable of advancing sampling tools below the ground surface to collect subsurface soil gas samples, subsurface soil samples, and groundwater samples. The information obtained from an investigation using these tools can be used to define the extent of contamination in the area, assist in determining the placement of monitoring wells and be used to install monitoring wells.

2 Definitions and Acronyms

DQO	Data Quality Objective
E & E	Ecology and Environment, Inc.
HSA	Hollow-Stem Auger
ID	Inside Diameter
IDW	Investigation-Derived Waste
OD	Outside Diameter
OSHA	Occupational Safety and Health Administration
PM	Project Manager
PVC	Polyvinyl Chloride
PRP	Potentially Responsible Party
SHASP	Site Specific Health and Safety Plan
SOP	Standard Operating Procedure
SSC	Site Safety Coordinator
TSP	Trisodium Phosphate
VOC	Volatile Organic Compound

3 Procedure Summary

The various direct-push units are hydraulically powered probing devices. The units consist of a powered percussion hammer that is slide-mounted on a derrick and has a nominal stroke ranging from 3.5 to more than 6.5 feet. The derrick assembly hydraulically folds and unfolds from the traveling or storage position in the rear compartment of a vehicle or onto the track-driven unit. The derrick is also adjustable in both the fore and aft directions, side to side as well as angled, to ensure the derrick is vertical during operations. Direct-push machines use the weight of the unit and a hydraulically powered percussion hammer to advance probe rods into the ground. The probe rods are hardened steel with various inside diameters (IDs) and outside diameters (ODs) ranging from 1 to 4.5 inches. The operator controls the hydraulic cylinders and the percussion hammer through the use of levers, and the helper assists by adding sections of rod. Depending on the purpose of the investigation, the lead rod will be equipped to collect soil, groundwater, or soil gas samples. After the lead rod has been driven into the ground, the helper attaches an additional section of rod and the process is repeated until the desired depth has been reached. Additionally, some direct-push machines are equipped with rotary heads that can be used for turning augers. Auger drilling, however, is not described in this SOP.

4 Cautions

Direct-push machines and sampling tooling provide a means of collecting subsurface samples that can be used to rapidly assess the presence of contaminants in near-surface unconsolidated soils. E & E's current Geoprobe® machine and associated tooling can penetrate much farther in moist, cohesive soils, as the probe hole tends to stay open in these conditions. Dry, loose soils tend to collapse onto the top of the sampling tool at depth, making it difficult to return the sampler through the collapsed probe hole to the ground surface. Tightly bound clay, rocky soils, and tightly compacted glacial till deposits may offer too much resistance to the sampling tools resulting in little or no advancement of tool strings. In these cases, other subsurface investigation methods (such as auger or rotary drilling) or larger direct-push machinery should be considered. Use of under-sized direct-push machines in these situations may result either in damage to the machine or injury to the operator.

Cautions associated with direct-push sample acquisition include decontamination procedures, depth control, and health and safety associated with heavy equipment use. All equipment that is brought on site must be clean prior to arrival and all downhole equipment must be decontaminated prior to drilling each boring location. This is an important factor to ensure that off-site contaminants are not introduced to the soils (and groundwater) being collected and that contaminants encountered at one site location are not spread throughout the site.

Depth control is also an important factor to ensure that exact soil horizons, formations, and zones of contamination identified during sampling are accurately documented and will allow for accurate placement of well materials. The operator and oversight geologist should be familiar with the drilling methodology and independently verify measurements on a regular basis.

As with any heavy equipment operation, proper personal protective equipment is essential. At a minimum, Level-D protection will be required for all probing operations.

5 Equipment and Supplies

Direct-push soil, soil vapor, and groundwater sample collection tools are typically proprietary to the manufacturer of the direct-push machine. Field sample collection typically involves a combination of non-expendable tooling and expendable sampler liners or tubing. The direct-push equipment and expendable supplies required for field work depend on the program/project DQOs, and may include:

- Sampler such as thin-walled tube sampler (e.g., shelby tube sampler), split-spoon sampler, continuous soil core sampler (e.g. Laskey), continuous-flight auger, or direct push soil corer (e.g., Dual Tube or Macro-Core®).
- Liners and/or catchers for augers or core samplers as specified in the project planning documents
- Tubing for the retrieval and collection of soil vapor and groundwater samples.

The following is a general list of equipment and supplies used to process samples of various media after they are originally obtained by the proprietary down-hole direct-push sample collection tooling. A detailed list of equipment and supplies should be prepared based on the project planning documents. In general, the use of dedicated or disposal equipment is preferred but equipment may be re-used after thorough decontamination between sample locations (refer to E & E Sampling Equipment Decontamination SOP ENV 3.15).

- Stainless-steel or Teflon™ spoons, trowels, or scoops. Other construction material may be acceptable depending upon the program/project planning documents and DQOs
- Stainless-steel mixing bowls. Other bowl construction material may be acceptable depending upon the program/project planning documents and DQOs
- Spade(s) and/or shovel(s)
- Pipe cutter(s), stainless steel knives(s), or power saw to cut liners
- Survey stakes or flags to mark locations
- Ancillary equipment and supplies, e.g., meter stick or tape measure, aluminum foil, plastic sheeting, disposable gloves.

Supporting equipment and supplies also may be required to address the following:

- Field logbooks and supplies (Refer to project planning documents and the E & E Field Activity Logbooks SOP DOC 2.1 for details)
- Decontamination equipment and supplies (Refer to project planning documents and E & E Sampling Equipment Decontamination SOP ENV 3.15for details)
- Sample containers, preservatives, and shipping equipment and supplies (Refer to project planning documents and the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for details)
- Waste handling supplies (Refer to project planning documents and E & E Handling Investigation-Derived Wastes SOP ENV 3.26 for details)

6 Procedure

The most accurate method for obtaining information on the characteristics of unconsolidated deposits is to collect representative samples of the soil at measured depths and at intervals that will provide a complete lithologic profile of the soils. E & E staff will use the following procedures for completing subsurface soil sampling:

- Review relevant project planning documents, e.g., work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, etc.
- Select the sampling procedure(s) that meet project DQOs.
- Refer to the E & E Field Activity Logbooks SOP DOC 2.1 for guidance on the types of information that should be recorded for each sample.
- Refer to the E & E Environmental Sample Handling, Packaging and Shipping SOP ENV 3.16 for guidance on how samples should be labeled, packaged, and shipped.

6.1 Responsibilities

6.1.1 Operator

The typical direct-push crew consists of an operator and a helper. The operator is responsible for the safe and efficient operation of the machine, and also performs the daily inspections and maintenance. In addition, the operator inventories the supplies and equipment daily and ensures that an adequate supply of expendable parts are available to complete the job.

The operator is responsible for completing the subsurface investigation in accordance with the site-specific work plan and in a safe manner consistent with the site health and safety plan. Routinely, the operator is also responsible for (1) the quality of the samples recovered; (2) compliance with the project's quality assurance/quality control requirements; and (3) completion of daily summary documentation of activities.

If the operator observes any unsafe or potentially dangerous situations, the operator will stop operations until the proper corrective actions have been taken. The operator has the authority to cease operations at any location if the operator concludes that the conditions are dangerous or could compromise the quality of the samples.

6.1.2 Helper

The primary function of the helper is to assist the operator in conducting the subsurface investigation. The helper is responsible for assembling, securing, and disassembling the rods and other sampling tools used in the investigation. The helper is also responsible for ensuring that all of the equipment is properly decontaminated and that all tools are in proper working order.

If the helper notices any unsafe or potentially dangerous situations, the helper will inform the operator immediately. The helper must be attentive to conditions around the direct-push machine because the operator will be concentrating on the operation of the unit.

6.1.3 Site Safety

The site safety coordinator (SSC) is responsible for ensuring that the subsurface investigation follows the procedures as outlined in the site-specific health and safety plan. The SSC, at the direction of the project manager (PM) will ensure that overhead and buried utilities (e.g., electrical lines, telephone lines, natural gas lines) have been identified and located prior to commencing the subsurface investigation (see Section 6.3.1 of this SOP). The SSC will be familiar with the operations of the direct-push machine and the potential hazards posed by its operation. In many cases, the operator or helper also serves as the SSC for the drilling contractor. In addition to direct-push contractor's PM, E & E is also responsible for all items described above to the extent practicable.

6.2 Planning the Survey

In planning for direct-push field activities, research should be conducted on governmental agency stipulations which may require drilling permits and/or drillers' licenses; local and regional geology and hydrogeologic conditions; historic records on the size of the site; past waste disposal practices; types of waste material disposed of at the site; and depth and orientation of waste material. Sites should be evaluated in terms of their hydrogeologic setting. This evaluation will help maximize the effectiveness of the survey, given site conditions.

6.2.1 Researching the Site

- Prior to designing the field survey, the following information should be collected, if available, from reconnaissance surveys, interviews, and research reviews:
- Verify whether permits will be required prior to conducting field activities. Additionally, some agencies require that persons operating direct-push machinery be licensed prior to conducting the proposed work. Requirements are typically enforced by state, county and municipal agencies; usually require fees; and occasionally require bonds and proof of insurance.
- Information on the types and locations of materials that may be buried on site to determine where subsurface investigations should not be conducted with a direct-push machine, and to identify the type(s) of samples to be collected;
- Information on the surface layout of the site being studied, including information on topography, site boundaries, and the locations of buildings, rail lines, overhead and buried utility lines (e.g., electric lines, pipelines, etc.), scrap disposal areas, vaulted sidewalks, and other structures that may prevent the proper operation of the direct-push machine; and
- Maps, drawings, photographs of the area, and historical aerial photographs may indicate previous disposal areas and poor waste disposal practices, and can also provide a base map for plotting data.

6.2.2 Defining and Mapping the Survey Site

After obtaining background data, the proposed sampling locations should be laid out based on the locations of buried material or expected soil, groundwater or soil-gas contamination. Safety and accessibility are other factors to consider when locating sampling locations.

6.3 Field Procedures

6.3.1 Overhead and Buried Utilities

The use of a direct-push machine on a site or project requires that special precautions be taken by both the operator and the helper. Electricity from electrical power lines and other utilities can shock, burn, and cause death. Applicable regulations and codes and good practice mandate that overhead and buried utilities must be located, noted, and emphasized on all subsurface investigation location plans and assessment sheets. When overhead electrical power lines exist at or near the site, consider all wires to be live and dangerous. Watch for sagging power lines before entering the site. Do not lift power lines to gain entrance; call the power company and ask them to raise the lines or de-energize the lines. Before raising the derrick near power lines, walk completely around the unit. Determine what the minimum distance from any point on the unit to the nearest power line will be when the derrick is being raised. Do not raise the derrick or operate the unit if this distance is less than 25 feet or, if known, the minimum clearance stipulated by federal, state, and local regulations. To avoid contact with power lines, never move the direct-push machine with the derrick in a raised position.

If there are any questions concerning the safety of drilling on sites near overhead power lines, contact the power company. The power company will provide expert advice at the site as a public service at no cost.

Underground electrical utilities are as dangerous as overhead power lines, but are not visible. Be aware and always suspect the existence of underground utilities. If a sign warning of underground utilities is located on a site boundary, do not assume that underground utilities are located on or near the boundary or property line under the sign. Always contact the owners of utilities and determine jointly the precise location of underground utility lines, and mark or flag the locations. Besides electrical, other utilities that need to be checked are gas, telephone, water, cable TV, fiber optics (very important because of the cost to repair them), and sewer.

Most states and some municipalities have universal one-call systems that are used to notify utility owners of proposed work in the vicinity of their buried facilities. In many places, laws exist that mandate a call to the one-call system prior to conducting any excavation, drilling or probing activities. Be warned, however, that not all entities that own buried utilities subscribe to the one-call systems. It is the responsibility of the company performing the intrusive work to identify all buried utilities in the area prior to commencement of field activities. Additionally, a nation-wide system has been implemented to notify owners of utilities in specific project areas. A universal telephone number of “811” is dedicated to this function. Additional information is available at www.call811.com. There is always a waiting period after the time of a utility locate request before the utility owners are required to have their facilities properly marked (usually two working days).

Typically, utility companies are required to locate their utilities from a right-of-way or easement to property lines of a facility or to a meter or regulator that may be located on private property. Locating redistributed utilities on private property is the responsibility of the property owner. However, potentially responsible parties (PRPs) are often uncooperative in marking their own utilities. Private locators may need to be contracted to survey areas that the utility locators and property owners will not.

6.3.2 Work Area Set-Up

Prior to beginning sampling operations with a direct-push machine, precautions should be taken to reduce physical risk in the work area. Situational awareness is paramount. Recognize that work is typically being conducted in a dynamic environment. Position the direct-push machine and support vehicles in a manner that will not interfere with traffic, or movement of other vehicles such as cars, trucks, forklifts, railcars, etc. Anticipate future traffic flow patterns and activities (e.g., don’t block facility egress routes, [especially at quitting time]). If street traffic is to be blocked, ensure that all requirements are met regarding signage and placement of traffic pylons. Additionally, wear safety vests in any area where traffic is anticipated.

6.3.3 Operating Direct-Push Machines

Refer to the operator’s manual of the specific Geoprobe® or other direct-push machine being used for specific operating procedures. Direct-push machines as with drill rigs and other machinery and tooling should only be operated by qualified personnel. As a courtesy, the following safety information for truck-mounted and track-mounted units was provided by Geoprobe Systems®:

6.3.3.1 Truck-Mounted Geoprobe® Safety

1. Always set the carrier vehicle parking brake and shut off the engine before exiting the cab. Refer to the carrier vehicle owner's manual for additional safety guidelines.
2. Heed all CAUTION, WARNING, and DANGER decals posted on the machine.
3. Operators should wear OSHA-approved steel-toed shoes and keep feet clear of probe foot.
4. Operators should wear OSHA-approved safety glasses at all times during the operation of this machine.
5. Operators must wear hearing protection. OSHA-approved hearing protection for sound levels exceeding 85 dba is recommended.
6. The Emergency Kill switch button on the control panel will immediately shut off the engine when pushed. Familiarize yourself with the location of this button before operating the machine.
7. Ensure that everyone is clear of all moving parts before starting the engine.
8. Do not drive the machine with the probe cylinder or winch mast extended. This practice could result in equipment damage and/or personal injury from contact with overhead objects such as power lines.
9. When operating the unit on sloped surfaces, always position the unit parallel with the slope. This provides the greatest degree of stability and will limit shifting during probing or augering operations. Position the machine with the control panel upslope whenever possible so the machine will roll away from the operator if it becomes unstable and moves unexpectedly.
10. Designate one person to operate the machine while probing or augering. This will avoid injuries from having someone unexpectedly engage the machine controls while another person is working near moving parts.
11. Operators must stand to the control side of the machine, clear of the probe foot and derrick, while operating the controls. Never reach across the probe assembly to manipulate the machine controls.
12. Never place your hands on top of the tool string while raising or lowering the GH60 hammer.
13. Never move the probe assembly (swing, extend, fold, etc.) while anyone is in physical contact with the tool string.
14. Use caution when probing on loose or soft surfaces. Reduced weight on the rear wheels may allow the carrier vehicle to shift or slide under such conditions.
15. Limit the rate at which the GH60 hammer is lowered while advancing the tool string to avoid raising the probe foot more than approximately 6 inches off of the ground surface.

16. Never raise the machine foot more than a few inches from the ground surface with the probe cylinder and/or winch mast fully extended. If the foot must be raised significantly, first lower the hammer and winch.

17. Always place the machine foot firmly on the ground when pulling tools from the subsurface.

18. In the event of a problem, the operator should release all control levers. The spring-loaded levers will automatically return to the neutral position and machine operation will cease.

19. Rotating parts can cause serious injuries. Shut off the engine before attempting to clean or service the unit.

20. Do not make modifications or add attachments to this machine which are not approved by Geoprobe Systems®.

21. Do not wear loose clothing while operating this machine. Severe injury will result if clothing becomes entangled in moving parts.

22. Avoid hydraulic fluid leaks. Pressurized fluid may be injected into the skin resulting in serious bodily injury. In the event of an accident, seek medical attention immediately.

6.3.3.2 Track-Mounted Geoprobe® Safety

1. Refer to the Kubota Diesel Engine Operator's Manual for all engine-related safety instructions before operating the Geoprobe® track-mounted machine.

2. Heed all CAUTION, WARNING, and DANGER decals posted on the machine.

3. Operators should wear OSHA-approved steel-toed shoes and keep feet clear of probe foot.

4. Operators should wear OSHA-approved safety glasses at all times during the operation of this machine.

5. Operators must wear hearing protection. OSHA-approved hearing protection for sound levels exceeding 85 dba is recommended.

6. The Emergency Kill switch button on the control panel will immediately shut off the engine when pushed. Familiarize yourself with the location of this button before operating the machine.

7. Ensure that everyone is clear of all moving parts before starting the engine.

8. Check that both outriggers are fully raised before attempting to drive the unit.

9. Do not drive the machine with the probe cylinder or winch mast extended. This practice could result in equipment damage and/or personal injury from contact with overhead objects such as power lines.

10. The unit should only be driven using the remote control box. The steering levers located on the machine are for positioning only. Do not attempt to drive using the levers on the machine as this requires the operator to walk too close to the tracks while the vehicle is in motion.

11. Do not attempt to drive the unit on slopes of more than 20 degrees. Always drive straight up or down steep grades. Avoid sideslopes whenever possible. Continuous operation should be limited to slopes of less than 20° to avoid engine damage.

12. When maneuvering the unit in close quarters, lower engine speed to provide more precise control of the track assemblies.

13. A track-mounted machine is generally transported on a trailer. Use special caution when loading the unit with wet ramps as it is significantly easier for the tracks to slip under such conditions.

14. When operating the unit on sloped surfaces, always position the unit parallel with the slope. This provides the greatest degree of stability and will limit shifting during probing or augering operations. Position the track-mounted machine with the control panel upslope whenever possible so the machine will roll away from the operator if it becomes unstable and moves unexpectedly.

15. Do not extend the outriggers such that the tracks are raised off of the ground more than one or two inches. Raising the tracks several inches off of the ground surface decreases the stability of the machine and provides no operational advantage.

16. Designate one person to operate the machine while probing or augering. This will avoid injuries from having someone unexpectedly engage the machine controls while another person is working near moving parts.

17. Operators must stand to the control side of the machine, clear of the probe foot and derrick, while operating the controls. Never reach across the probe assembly to manipulate the machine controls.

18. Never place your hands on top of the tool string while raising or lowering the GH60 hammer.

19. Never move the probe assembly (swing, extend, fold, etc.) or operate the tracks while anyone is in physical contact with the tool string.

20. Use caution when probing on loose or soft surfaces. Reduced weight on the tracks may allow the unit to shift or slide under such conditions.

21. Limit the rate at which the GH60 hammer is lowered while advancing the tool string to avoid raising the probe foot more than approximately 6 inches off of the ground surface.

22. Never raise the machine foot more than a few inches from the ground surface with the probe cylinder and/or winch mast fully extended. If the foot must be raised significantly, first lower the hammer and winch.

23. Always place the machine foot firmly on the ground when pulling tools from the subsurface.

24. In the event of a problem, the operator should release all control levers. The spring-loaded levers will automatically return to the neutral position and machine operation will cease.

25. Rotating parts can cause serious injuries. Shut off the engine before attempting to clean or service the unit.
26. Do not make modifications or add attachments to this machine which are not approved by Geoprobe Systems®.
27. Do not wear loose clothing while operating this machine. Severe injury will result if clothing becomes entangled in moving parts.
28. Avoid hydraulic fluid leaks. Pressurized fluid may be injected into the skin resulting in serious bodily injury. In the event of an accident, seek medical attention immediately.

When using a subcontractor to perform direct-push operations, the subcontractor's SOP must be included in their site-specific health and safety plan. These procedures in addition to those described in E & E's site-specific work plan must be followed.

6.4 Subsurface Soil Sampling

Direct-push machines can be used to collect subsurface soil samples. Soil samples are typically collected in steel sampling tubes that are fitted with a PVC, Teflon, or other liner manufactured from various polymers. Once the sampler is driven to depth then retrieved, the liner containing the soil core is removed and the sampler is reloaded with a new liner. Most commonly, soil samples are collected by advancing an open-ended soil sampler from the ground surface to a depth equal to the length of the sampler. The sampler is then removed from the ground leaving an open probe hole. The soil core is removed from the soil sampling tool, the open-ended sampler is reassembled, and advanced through the open probe hole to the next deeper sampling interval. This process is repeated until the desired depth is reached. In the event that the probe hole collapses or only one discreet sampling interval is desired, a closed-piston soil sampler can be used to advance the sampler to a specified depth without allowing soil into the sampler until the closed tip is deployed by the operator, allowing soil into the core liner. Additionally, dual tube sampling systems are available that case the probe hole as the soil sampling depth increases, preventing the inadvertent collapse of the probe hole during sampling operations.

Soil samplers ranging in size from one-inch OD to 4.5-inch OD are available. Each soil sampling tool is used in conjunction with specific combinations of direct-push machines and probe rods. Soil can be collected using open- and closed- tip samplers as described above. See manufacturer's operating instructions and tooling requirements for specific sampling equipment.

6.5 Groundwater Sampling

Direct-push machines can be used to advance sampling tools that are specifically designed for the collection of groundwater. Each groundwater sampling tool is combined with probe rods to access saturated zones and to provide a conduit for sample retrieval. A bailer, tubing attached to an above-ground pump (e.g., peristaltic pump), or tubing with a check valve at its base is required to retrieve groundwater from the sampling tool/probe rod combination. Groundwater sampling tools fall into two categories; those that have exposed "well slots" and those that are sheathed or protected from contacting soil and groundwater while being driven to their final depth.

A mill-slot groundwater sampler is essentially a probe rod that has a series of thin slots cut into its sides to allow for the passage of groundwater into the probe rods. Typically, the lead “mill-slot” rod is tipped with a threaded point to prevent the intrusion of soil into the bottom of the sampler while driving the rods to their final depth. In the event that the probe hole needs to be grouted from the bottom to the surface after groundwater sample collection, the threaded point can be substituted with an expendable point that is deployed by the operator prior to grouting operations. Grout is pumped through the probe rods while they are retracted from the ground. Mill slot samplers typically work better in coarse-grained soils. If used in cohesive soils, the slots can become smeared or plugged, limiting the passage of water into the probe rods.

A sheathed sampling tool consists of a well screen inserted into an outer sheath tipped with an expendable point. The sampling tool is advanced in the closed position to the desired sampling interval. The expendable point is deployed by the operator and the probe rods are retracted the length of the sampling screen. Retracting the probe rods cause the sheath to also retract. This operation exposes the well screen to the saturated formation allowing groundwater to enter the screen. If grouting of the probe hole needs to be conducted, a plug located at the bottom of the well screen is knocked out by the operator, allowing grout to be pumped through the tool string into the probe hole as the rods are being removed from the ground. Sheathed samplers work well in most formations that will produce pumpable water. However, because of the extra steps involved in deploying the well screen, set-up time is greater than that of a mill-slot sampling tool.

6.6 Soil-Gas Sampling

Direct-push machines can be used to advance sampling tools that are specifically designed for the collection of discrete soil-gas samples. Soil gas is drawn from a discreet subsurface sampling point to the surface using a vacuum pump that is mounted on the direct-push unit. Three soil gas sampling tools are typically used; one type uses the probe rods as the conduit for transporting soil gas to the surface and two types use polymer tubing to transport soil gas to the surface. See specific instructions provided by the manufacturer of the samplers that are being used.

The method that uses the probe rods as a conduit consist of a retractable point, a string of probe rods, and a threaded top cap fitted with a barbed tubing connector. The sampling point is advanced to the desired sampling depth (in an unsaturated zone) in the closed position. The probe rods are then retracted to open the soil gas sampling point. The top cap is then threaded to the top of the probe rod and the vacuum pump is connected to the fitting with flexible tubing. Soil gas is then evacuated from the probe rods using the vacuum pump. A sample can be collected by placing the sample container in-line between the probe rods and the vacuum pump. Alternatively, samples can be collected by placing a pre-evacuated sample container (e.g., Summa canister) directly on the probe rod top cap after a predetermined number of probe rod volumes is purged using the vacuum pump.

One of the sampling methods that employ polymer tubing also uses a retractable point as described above. However, polymer tubing is lowered through the probe rods when the desired sampling depth is reached and is attached to the upper end of the retractable point (inside of the probe rods). The polymer tubing that extends beyond the top of the probe rods is attached to the vacuum pump. Purging and sampling is subsequently conducted as described above. Upon completion of sample collection, the probe rods and retractable point are removed from the probe hole, along with the tubing.

In the other soil gas sampling method that uses polymer tubing, probe rods are used to deploy small diameter screens at the selected soil gas sampling interval. Tubing is attached to the top end of the soil gas sampler screen and the probe rods are removed from the ground leaving the sampler and tubing in place. This method usually requires that the annular space of the hole be sealed to prevent the downward migration of gas along the outside of the tubing. The polymer tubing that extends beyond the ground surface is then attached to the vacuum pump. Purging and sampling is subsequently conducted as described above.

6.7 Abandonment of Probe Holes

Before probe holes can be abandoned, regulations from the appropriate governmental agency with regulatory authority in which the soil boring and well abandonment will be performed should be consulted. Each agency may have specific regulations for soil boring and well abandonment, and these regulations can dictate the method and material that will be used to plug the probe holes. However, in most cases, the regulatory authority will require that the probe holes be backfilled with some sort of bentonite clay (granular, chips, or a slurry). Geoprobe Systems® as well as other manufacturers have pumps designed specifically for the grouting of probe holes.

Any soil or groundwater removed from the earth during the sample collection procedures may be considered investigation-derived waste (IDW). It is imperative that IDW handling procedures be addressed prior to conducting any field sampling activities.

6.8 Decontamination

Decontamination requirements will be determined on a site by site basis, and will be dependent on both the subsurface conditions and nature of the investigation. Standard operating procedures will be employed to minimize the degree of possible cross-contamination and IDW production. The following decontamination methods or a combination of the methods are typically used.

The direct-push machine and all appurtenances must be decontaminated prior to arrival on site. All equipment will be decontaminated again upon arrival to the site to remove road dirt only. Moreover, it is the operator’s responsibility to decontaminate all equipment prior to leaving the site.

Decontamination of the direct-push unit and all down-hole equipment will consist of:

- Removal of foreign matter;
- Scrubbing with brushes in TSP/water solution (Alconcox);
- Rinsing in potable water; and
- Final rinse with Distilled/Deionized water.

Once clean, no equipment may touch the ground prior to use. The equipment must be stored on the direct-push machine tool rack, support truck, or on plastic sheeting.

* Note: Geoprobe® soil, groundwater and soil gas sampling equipment/methodology are being continuously improved. To obtain current information regarding Geoprobe® operation or description of sampling equipment go to www.geoprobe.com.

7 Quality Assurance/Quality Control

Prior to initiating field work, the project planning documents (e.g., work plan, sampling and analysis plan, quality assurance project plan, SHASP, *et al*) should be reviewed by field personnel to identify sampling procedure(s) that will most likely provide surface and shallow subsurface soil samples that meet project DQOs.

The program/project manager should identify personnel for the field team who have knowledge, training and experience in the direct-push sample collection methodologies being conducted (typically a trained geologist). The geologist should document all borehole sampling and lithological information in E & E's geotechnical logbook. All project personnel, if necessary, can complete ancillary procedures, e.g., field logbook documentation, equipment decontamination, sample shipment, and waste disposal.

The lead geologist should prepare a detailed equipment checklist before entering the field and verify that sufficient and appropriate equipment and supplies are taken into the field.

Quality assurance/quality control samples (e.g., co-located samples) are collected according to the site quality assurance project plan. Field duplicates are collected from one location and treated as separate samples. Field duplicates are typically collected after the samples have been homogenized. Collocated samples are generally collected from nearby locations and are collected as completely separate samples. Rinsate blanks may be necessary to evaluate the effectiveness of field decontamination procedures (see E & E SOP Env 3.15).

In cases where multiple hand-collected scoop, auger or core samples are required to generate an adequate sample volume, homogenization is important. Field personnel should collect sample aliquots only after mixing has produced soil with textural and color homogeneity.

At sites with known or suspected contamination, samples should be collected moving from least to most contaminated areas.

8 Health and Safety

Prior to entering the field, all field personnel formally acknowledge that they have read and understand the project specific health and safety plan.

Direct-push machinery and tooling are inherently dangerous pieces of heavy equipment which a high "pinch" potential. Care should be taken at all times when handling such equipment, not just during sample collection.

Prior to any subsurface work, verify that underground utilities have been located and marked as described in Section 6.3.1.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be entered in this section and included with the project planning documents.

10 References

See E & E SOP Env 3.13 for additional sources of technical information on soil sampling.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

MEASURING WATER LEVEL AND WELL DEPTH

SOP NUMBER: GEO 4.15

REVISION DATE: 4/3/2013 **SCHEDULED REVIEW DATE: 4/3/2018**

Contents

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1 Scope and Application

Most subsurface investigations require measurement and monitoring of groundwater levels to characterize contaminant movement and aquifer conditions as they relate to specific investigation sites. This document describes E & E's standard operating procedure (SOP) for measuring water level and well depth in monitoring wells and piezometers.

2 Definitions and Acronyms

BGS	below ground surface
DNAPL	dense non-aqueous phase liquid
LNAPL	light non-aqueous phase liquid
MSL	mean sea level
SOP	Standard Operating Procedure
TOC	top of casing
TOIC	top of inner casing (i.e., top of the well casing inside the outer protective casing)

3 Procedure Summary

Water level and total well depth measurements in monitoring wells are performed by using a water level indicator that has a graduated cable, typically to the nearest 0.01 foot. The precision of the device selected for measurement should be determined at the time of data quality objective development for the specific project. Water level and total depth measurements must be referenced to a consistent, repeatable, and known reference point. Typically, this is the top of (TOC) of the well or piezometer, which in many cases is more specifically the top of inner casing (TOIC) of the well or piezometer because most wells have an outer protective casing. The measurement reference point may also be ground surface, especially if the well is completed with a flush-mount cover. Measurements referenced to ground surface are typically reported in feet or meters below ground surface (BGS). Measurements of groundwater head elevation are typically required to determine flow gradients and other hydraulic properties. Therefore, the elevation of the measurement reference point may be determined via vertical surveying of the reference point. The resulting elevation of the reference point and groundwater level must reference the appropriate datum used to develop the elevations. This may be a local site datum of an assumed value or mean sea level (MSL) referenced to an ellipsoid such as the World Geodetic System 1984 or a geoid such as the North American Vertical Datum 1988. The water level indicator must be decontaminated according to E & E SOP for Equipment Decontamination (ENV 3.15) between each use in different well.

4 Cautions

If a noticeably anomalous depth to water or well depth is encountered (based on previous measurement, well logs, or comparison of data to other nearby wells of similar construction), re-measure and verify the measurements before leaving the site.

Because some casings have rough or sharp edges, use caution when lowering and retrieving the water level cable from within the well casing. These edges can cut and scrape the cable, obscuring the calibrated markings on the cable, and can eventually lead to failure (shorting out) of the electronic cable.

The top of well casings may not be level (due to imperfections when the casing was cut to length at the time of well installation). Therefore, a mark should be placed on the top of the casing to be used as a reference point for measuring. If a mark is not present, assume the measurement was taken at the highest point on the top of the well casing, because this is likely the point surveyed.

Always use caution when opening capped wells, because escaping (venting) headspace gases may be hazardous.

Changes in atmospheric pressure may cause the monitoring well to be under pressure or under vacuum if a gas-tight cap is present. This can result in a temporarily high or low water level within the well. Often the sound of air escaping from the well can be heard from the well when the cap is removed. If a sealed, gas-tight cap or plug is present, the water level within the well should be allowed to equalize to atmospheric pressure before collecting a depth to water measurement. Only stabilized measurements should be recorded.

5 Equipment and Supplies

The following is a list of equipment and items typically used for measuring water levels and well depths:

- Electronic water level indicator or oil/water interface probe with graduated cable;
- Extra batteries for water level indicator or oil/water interface probe;
- Detergent solution (laboratory grade, phosphate-free detergent such as Liquinox);
- Deionized or distilled water;
- Sterile gloves (nitrile or other material suitable to site conditions);
- Paper towels;
- Logbook and other site documentation; and
- Folding ruler or pocket steel tape.

6 Procedures

6.1 Preliminary Steps

1. Locate the well or piezometer and verify its position on the site map. Record whether positive identification was obtained, including the well number and any identifying marks or codes contained on the well casing or protective casing. Gain access to the top of the well casing and note the date and time the well was opened. If specified in the work plan or site health and safety plan, use monitoring equipment to measure or take readings of the well headspace. Record all measurements and observations (e.g., organic vapor readings, release of pressure when cap is removed, odor, etc.).
2. Locate and record the specified benchmark or survey point for the well or piezometer, which may be a mark at the top of the casing or a surveyor's pin embedded in the protective structure. Determine the elevation of this point from the records (if available) and record in the notebook. Measure and record the vertical distance from the benchmark to the top of the well casing to the nearest 0.01 foot. Measure and record

the metal casing stickup (i.e., the distance between the top of the casing and nominal ground level).

3. Record any observations and remarks regarding the completion characteristics and well condition, including evidence of cracked casing or surface seals, security of the well (locked cap), and evidence of tampering.
4. Decontaminate all portions of the equipment that will enter the well according to E & E SOP ENV 3.15. Keep all equipment and supplies protected from contamination when not in use.
5. If free product is suspected to be present in a monitoring well, an oil/water interface probe will be used to measure the thickness of light non-aqueous phase liquid (LNAPL), which floats on top of the water table, or Dense Non-Aqueous Phase Liquid (DNAPL), which will collect in the bottom of the well. Procedures for operating an oil/water interface probe are described below.

6.2 Operation

1. Remove the water level indicator probe from the case (if so equipped), turn on the sounder, and test the battery and audio-visual indicator by pushing the test button. Adjust the sensitivity scale until you can see and/or hear the indicator. Release the test button if successful. If the indicator does not sound or illuminate, turn up the sensitivity until it does. If the indicator still fails to sound or illuminate, check and replace the batteries as needed.
2. Slowly lower the probe into the well, allowing the cable reel to unwind slowly and do not allow the cable to rub on any sharp casing edges. Continue lowering the probe until the indicator sounds and/or illuminates. Raise and lower the probe very slowly at least two additional times until the indicator sounds/illuminates at a consistent depth. False signals may be encountered by moisture in the inside walls of the well casing above the level of groundwater. Make note of the depth reading on the cable at the reference point on the well casing or mark the spot on the cable by grasping it with the thumb and forefinger at the top of the casing and withdrawing the cable to note the measurement. Record the depth measurement in the logbook or other site documentation. Be careful to read the tape properly from bottom to top (e.g., a water depth of 11.50 feet could be mistaken for 12.50 feet if the operator looks at the tape from the top down rather from the bottom up).
3. Use of an oil/water interface probe is similar to that of an electronic water level indicator in that the probe has a graduated reel tape, typically also in increments of 0.01 foot. Lower the probe into the well slowly so as not to disperse an LNAPL on the water surface. When the probe comes in contact with LNAPL, it will emit a solid tone. Record the depth at which this is encountered as described in Number 2 above. Next, continue to lower the probe slowly to the depth at which the probe emits a beeping or non-continuous tone. This is the interface between the LNAPL and water table. Record this measurement as described above. The difference between these two measurements is the LNAPL thickness within the well. Similarly, DNAPL may be encountered at the bottom of a well at some project sites. In this case, the beeping tone will change to a solid tone within the water column of the well. Record this depth and the total depth of the well to determine the DNAPL thickness. Use caution when sounding the total depth of the well so as not to damage the probe sensors.

4. To measure the total well or piezometer depth, lower the probe until slack is felt in the cable. The indicator on the probe may be turned off prior to taking this measurement. Very slowly raise and lower the cable until the bottom of the well is detected and no more slack is felt in the cable. If there is soft sediment on the bottom of the well, it may be difficult to determine the exact depth. Note this condition in the site logbook. As described above, note the measurement on the cable at the reference point or grasp the cable with the thumb and forefinger at the top of the casing and note the depth. IMPORTANT: the “zero” reference point on the probe may not be at the bottom of the probe (e.g., Solinst Model 101 probes have a weighted stainless steel tip that extends 0.28 feet or 8.53 centimeters beyond the calibrated "zero" point of the measuring cable). If this is the case, use the cable to accurately measure the distance from the end of the weight to the water level sensor and add this length to the measurement noted above. Record the sum of these two lengths as the total depth of the well.
5. Withdraw the cable and probe, and decontaminate according to the SOP for Equipment Decontamination (ENV 3.15).

6.3 Data Recording and Manipulation

Record the following computations, first ensuring that all measurements are in the same units:

- Measurement reference point (e.g., TOC) elevation, as determined by site survey or from site documentation
- Water level elevation = [TOC elevation] - [depth to water]
- Total well depth = [cable-measured depth from top of casing] + [correction factor (as described above) for length of probe below the water sensor]
- Well bottom elevation = [TOC elevation] - [total well depth]
- If an oil/water interface probe is used, record readings as described in Section 6.2 (3).

In the presence of LNAPL, groundwater elevations need to be corrected to account for displacement caused by the product. To make the corrections, perform the following computation:

- Corrected water level elevation = [LNAPL thickness] x [LNAPL specific gravity] + [calculated groundwater level elevation (as described above)]

6.4 Calibration

No calibration is needed for the electronic water level indicator; however, a check of the responsiveness of the indicator must be performed.

7 Quality Assurance / Quality Control

Check functionality of the water level indicator or oil/water interface probe by pressing the test button, and if necessary, by dipping the probe in a jar or bucket of water to check responsiveness. Note condition of measuring cable/tape (i.e., make sure the numbers are readable. Lastly, if a noticeably anomalous depth to water or total depth is encountered (based on previous measurements, well logs, or comparison of data collected from other nearby wells of similar construction), re-measure before leaving the site.

8 Health and Safety

Comply with the general and site-specific health and safety protocols described in the site-specific health and safety plan. Wells may be located in a variety of settings each with their own safety concerns, such as traffic, animals, etc. Be wary of the presence of insects (e.g., ants, bees, wasps) that may be in the well via holes or cracks in the riser or riser cap. Additionally, be prepared for the presence of gases that may have built up in the well while it was sealed. If gases from the well are expected or detected, keep a safe distance once the riser cap is removed and allow the well to degas before continuing with water level measurements.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be included with the project planning documents.

10 References

None.

END OF SOP

ecology and environment, inc.

STANDARD OPERATING PROCEDURE

EVALUATION OF EXISTING MONITORING WELLS

SOP NUMBER: GEO 4.19

REVISION DATE: 4/2/2013 **SCHEDULED REVIEW DATE: 4/2/2018**

Contents

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1 Scope and Application

The purpose of this Standard Operating Procedure (SOP) is to establish protocols for determining the integrity of existing monitoring wells. Existing wells represent valuable sources of information for subsurface environmental investigations and may provide the following information:

- Subsurface lithology and hydrogeology based on existing logs;
- Access for downhole geophysical logging or hydraulic testing (e.g., slug and pump tests);
- Monitoring of water levels for development of potentiometric surface maps and interpretation of groundwater flow direction;
- Regional drinking water quality may be evaluated and monitored; and
- Mapping and monitoring changes in contaminant plumes.

Data from existing wells should only be used when the characteristics of the wells have been sufficiently documented to determine that they satisfy the data quality objectives of the investigation.

Guidance for planning appropriate data quality objectives may be found in USEPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process* (2006). The selection of wells and a description of well documentation procedures may be found in ASTM's *Standard Guide for Selection and Documentation of Existing Wells for Use in Environmental Site Characterization and Monitoring* (1996).

This SOP is intended for use by personnel who have knowledge, training and experience in the monitoring well installation and maintenance activities being conducted.

2 Definitions and Acronyms

ASTM	American Society for Testing and Materials
SOP	Standard Operating Procedure
USEPA	United States Environmental Protection Agency

3 Procedure Summary

Prior to inspecting wells, a review of project planning documents and existing site documentation (including, if available, previous sampling and analysis results, well drilling/installation logs, etc.) is important and should be performed. This will allow the inspector to properly identify the location of the well, confirm the well ID, anticipate the depth and construction of the well, allow the well to be opened with the proper keys and tools, and whether contamination will be a health and safety issue. Once on site, the inspector should focus on the following:

a. Well identification;
b. The condition of the protective casing, cap, and lock;
c. The condition of the drainage pad surrounding the protective casing;

d. The presence of depressions or standing water around the casing;

e. The condition of the inside well casing; and

f. The depth to water and total well depth.

The final inspection shall include opening the well, and measuring and recording the depth to water and total depth as per E & E's SOP for Measuring Water Level and Well Depth (GEO 4.15).

4 Cautions

Cross-contamination of wells can occur if probes or other down-hole tools are not properly decontaminated between well inspections. Low-quality or unusable analytical data may result if samples are collected from wells where the well integrity has not been properly characterized. Additionally, loss or damage of equipment may occur if obstructions in the well are not properly identified.

Also refer to the cautions described in E & E's SOP for Measuring Water Level and Well Depth (GEO 4.15) for information related to down-hole measurements.

5 Equipment and Supplies

a. Field logbook and other site documentation;
b. Indelible black ink pen;
c. Organic vapor meter (e.g., photo- or flame-ionization detector);
d. Water level indicator or oil/water interface probe, as appropriate for site conditions
e. Steel tape or folding ruler;
f. Flashlight;
g. Deionized or distilled water;
h. Extra batteries for water level indicator;
i. Camera;
j. Well lock keys; and
k. Tools to open flush-mount well covers or cut-off well locks.

6 Procedures

The following steps shall be conducted for each well inspection:

1. Review the original work plan for monitoring well construction and installation details, if available. The physical features which must be identified and detailed include:
   a. Well identification number, permit number, and location by referenced coordinates or as related to prominent site features;
   b. Installation dates, drilling methods, and contractors;
   c. Depth to bedrock (if applicable).
   d. Borehole depth and diameter;
   e. Well completion type (stick up or flush mount);

   f. Depth of bottom of well;
   g. Type of well materials, screen type and length, and elevation of top and bottom of screen;
   h. Depths of tops and bottoms of well seals and filter packs.

2. Conduct an on-site inspection of existing monitoring wells. Prior to opening the well, features to be noted include:
   a. The condition of the well identification marks, protective casing, cap, and lock;
   b. The condition of the concrete drainage pad surrounding the protective casing;
   c. The presence of depressions or standing water around the casing; and
   d. The presence of any electrical cables (for pumps or transducers) and its connections.

   Record the above and subsequent observations described below in the field logbook, on data collection forms, and/or in the form of annotated sketches. An example Well Inspection Checklist is attached at the end of this SOP.

3. Remove the lock and/or open the protective cover. For flush-mount completions, note whether water is present within the annular space between the well casing and protective cover and whether the inner well cap is present and sealed. Remove water from the annular space using a cup, basting syringe, or other suitable method prior to removing the inner well cap. Check for the presence of organic vapors in the headspace at the top of the inner casing to determine the appropriate worker safety level, if required by the project planning documents. Record the following information:
   a. Presence, condition, and type of the inner well cap, including whether the cap is vented;
   b. Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space;
   c. Presence of grout between the riser and outer protective casing and the presence or absence of drain holes in the protective casing;
   d. Presence of dedicated sampling equipment (bailer, pump, tubing, rope, etc.); if possible, remove such equipment and inspect size, materials of construction and condition.
   e. Any other pertinent observations.

4. Measure depth to water and total depth of the well (see E & E SOP GEO 4.15). Note observations made during measurements such as the presence of soft sediment at the bottom of the well, obstructions that prevent measuring to the bottom of the well, etc.

5. Photo document the well conditions.

7 Health and Safety

Comply with the general and site-specific health and safety protocols described in the site-specific health and safety plan. Wells may be located in a variety of settings each with their own safety concerns, such as traffic, animals, etc. Be wary of the presence of insects (e.g., ants, bees, wasps) that may be in the well via holes or cracks in the riser or riser cap. Additionally, be prepared for the presence of gases that may have built up in the well while it was sealed. If gases from the well are expected or detected, keep a safe distance once the riser cap is removed and allow the well to degas before continuing with water level measurements.

8 Quality Assurance / Quality Control

Refer to E & E SOP GEO 4.15 for QA/QC issues associated with measurement of depths to water and total wells depths. In addition, it is important to verify the correct well identification prior to recording observations. Where well clusters are present but lack identification, prior knowledge of the well depths are important to allow for proper identification of the well.

9 Special Project Requirements

Project or program-specific requirements that modify this procedure should be followed and included with the appropriate project planning documents.

10 References

American Society for Testing and Materials, 1996, *Standard Guide for Selection and Documentation of Existing Wells for Use in Environmental Site Characterization and Monitoring*, Designation D5980-96.

United States Environmental Protection Agency, February 2006, *Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4*, Office of Environmental Information Washington, DC 20460, EPA/240/B-06/001

Well Inspection Checklist

Site Name & Location: ____________________

Well Number	Inspection Date	Time	Depth to Water (feet TOIC)	Total Depth (feet TOIC)	Well Paint (G/F/P)	Well Label (G/F/P)	Completion (s/u or curb)	Concrete Pad (G/F/P)	Casing Lock (G/F/P)	Protective Cover (G/F/P)	Inner Well Cap (G/F/P)	Obstructions in Well (Y/N)	Water in Annulus (Y/N)	Equipment in Well	Comments/Other Observations

Key:

curb =	curb box/flush-mount	N =	No	TOIC =	Top of inner casing
F =	Fair	P =	Poor	Y =	Yes
G =	Good	s/u =	stick-up		

Name & Affiliation of Inspector(s): ____________________

____

END OF SOP

1 Scope and Application

Proper documentation of field activities is a critical component of any field effort. This Standard Operating Procedure (SOP) establishes procedures for initiating, entering information/data into, reviewing, and maintaining/storing hard-copy field logbooks for E & E field activities. Field activities may range from simple reconnaissance to complex sampling programs. Such activities may include visual or other observations, *in situ* or *ex situ* field measurements (monitoring), biological surveys, or sample collection, as well as meetings and consultations with E & E clients, subcontractors, or other stakeholders.

Field logbooks are most commonly used for projects involving sampling, monitoring, or surveying but are also used for field activities such as a scoping site visit or oversight/ observation of engineering or construction contractors. A logbook is required to be maintained unless an approved project plan specifically eliminates the requirement. The SOP for documenting E & E activities outside of an E & E office that do not include the field activities discussed in the SOP herein is E & E SOP DOC 2.7 (Activities Log).

Field logbook documentation may be supplemented by other records (e.g., site safety forms, data collection forms, electronic data, or geotechnical logbooks). Information and data to be recorded on such forms or logbooks are addressed in the applicable SOPs.

Field observations, measurements, and samples have value to data users only to the degree that the observation, measurement, or sample is representative of a specified environment, setting, or process. Field logbooks address representativeness by documenting:

- Identification of the subject of the observation, measurement, or sampling;
- Selection of an observation, measurement, or sampling location and time that represents that subject;
- Compliance with or deviation from the work plan, sampling and analysis plan, quality assurance project plan, or other project or program plans; and
- Sufficient documentation of how the observation, measurement, or sample represents the same subject as other observations, measurements, or samples from the vicinity.

Complete, accurate, and precise logbook entries provide a legally defensible record of field activities, quality control (QC), decisions and their rationale, approved changes to planned activities, and meetings and communications. Well-written logbooks allow individuals not involved with a project to independently reconstruct the salient field activities at a later date.

This SOP is intended for use by personnel who have knowledge, training, and experience in the field activities being conducted.

2 Definitions and Acronyms

DI	Deionized
Field	Locations (sites) outside the controlled environment of an office or laboratory
Field observation	Qualitative and/or quantitative remark/statement regarding sensory inputs noted in the field

Field measurement	Quantitative determination of physical, chemical, biological, geological, or radiological properties of a matrix by measurement made in the field
Field sampling	Process of obtaining a representative portion of an environmental matrix suitable for laboratory or field measurement or analysis
E & E	Ecology and Environment, Inc.
EPA	(U.S.) Environmental Protection Agency
GPS	Global positioning system
ID	Identification
IDW	Investigation-derived waste
PM	Project manager
QA	Quality assurance
QC	Quality control
SOP	Standard operating procedure

3 Procedure Summary

E & E's Quality Management Plan gives the E & E project manager (PM) the authority to directly implement the project work activities necessary to meet technical and quality objectives. Project implementation requires, among other things, that the PM hold a kickoff meeting with appropriate team members to discuss work requirements, QC requirements and results, individual responsibilities, plans and schedules, work progress, and reporting requirements.

Prior to field activity, the PM identifies field personnel, a field team leader, and team members responsible for documenting field activities. Since there may be multiple activities with unique logbooks, there may be multiple team members responsible for documenting field activities.

The individual responsible for documenting field activities or other designated author should briefly summarize in the logbook the field activities that are planned to be conducted.

Visual or other observations, *in situ* or *ex situ* field measurements (including instrument and equipment calibrations), surveying, and sample collection information should be recorded in real time as fieldwork is conducted. Meetings, including electronic communications, with E & E, client, subcontractor, regulatory, or other personnel should be recorded. Compliance with or deviation from the work plan, sampling and analysis plan, quality assurance project plan, or other project or program plans should be documented, together with authorization for such deviations.

The field team leader and/or PM should review logbook entries on a routine basis.

4 Cautions

Logbook entry must be a priority and not left to "later." Contemporaneous documentation is important to achieve complete, accurate, and precise reporting.

Field logbooks become part of the permanent record for projects/programs and, thus, should include factual material, not opinions. Language used in logbooks should be objective and factual. Pertinent personal observations may be included, but must be clearly identified as such.

If multiple logbooks are used, a project logbook should be used to maintain control of all other logbooks.

Do not leave blank line(s) between logbook entries. Cross out blank spaces with a single line, and sign and date the cross out.

Initials should not be used in place of signatures unless specifically allowed by client requirements. Logbooks are considered evidentiary files and full signatures are required under judicial review guidelines (see EPA NEIC Policy, EPA 1991). If initials are used, a table of signatures and initials for project personnel should be recorded in the logbook.

5 Equipment and Supplies

Logbooks must be bound with consecutively numbered pages.

Entries should be made using indelible ink (preferably black).

6 Procedure

6.1 General Requirements

- Logbooks will be assigned by the PM to the field team leader. Additional logbooks may be assigned to other personnel (e.g., health and safety monitors). The PM is responsible for tracking field event logbooks.
- A separate field logbook must be maintained for each project.
- Logbook entries must be legible.
- The first entry for each day will be made on a new, previously blank page.
- No pages may be removed for any reason, even if mutilated or illegible. If a page or portion of a page is accidentally skipped during fieldwork, it should be crossed out, signed, and dated.
- Entries should be made in chronological order. Observations that cannot be recorded during field activities should be recorded as soon as possible. If logbook entries are made after field activities, the time of the activity/observation and the time that it is recorded should be noted.
- The time of each entry should be noted. It is customary to record time using a 24-hour clock.
- If corrections are necessary, they must be made by drawing a single line through the original entry in such a manner that it can still be read. Do not erase or render an incorrect notation illegible. The corrected entry should be written beside the incorrect entry, and the correction initialed and dated. Corrected errors may require a footnote explaining the correction.
- Each logbook page used during the day should be signed and dated at the bottom of each page at the end of each day (if more than one person makes entries into the logbook, each person should sign and date next to his or her entries). Signatures should be written along a single diagonal line drawn across the blank portion of any partially filled page following the last entry of the day.

- If multiple personnel are anticipated to make entries in a logbook, then a table of printed names, signatures, and initials should be recorded in the logbook.
- The field team leader should review logbook entries on a daily basis, or more frequently if appropriate. The PM should review the logbook on a weekly basis and at the close of fieldwork.
- At the completion of the field activity, the logbook must be returned to the PM to include with the project files.

6.2 Format

The following instructions provide a general format for recording a field event in a field activity logbook:

- Title Page

  The logbook title page should contain the following items:

  - Site name,
  - Site identification (ID) number,
  - Location,
  - Project name and number,
  - Start/finish date (may be completed at the end of the project), and
  - Book ___ of ___ (may be completed at the end of the project).

- First Page (for each day in the field)

  The following items should appear on the first page of the logbook prior to daily field activity entries (can be completed prior to entry into the field):

  - Date (at top of page),
  - Project name and number (at top of page),
  - Key project contact names and contact information (e.g., phone numbers),
  - General summary of proposed work (reference work plan and other documents, as appropriate), and
  - Team members and duties.

- Successive Pages (for each day in the field)

  In addition to specific activity entries and observations (refer to the remainder of Section 6 below), the following items should appear on every logbook page:

  - Date, project name, and project number at the top of each page,
  - Signature and date at the bottom of each page (if more than one person makes entries into the logbook, each person should sign and date next to his or her entries), and
  - Strikethroughs of any unused lines.

- Last Page (of project logbook entries)
    - The last page should indicate if work is continuing in subsequent logbooks or if the project is complete.

6.3 Logbook Information

Field logbook entries will contain a variety of information based on the field activities conducted (e.g., observing, monitoring, surveying, or sampling) and project requirements. In general, information recorded on field forms or electronic data does not need to be recorded in the logbook. Information also can be recorded on the first day of the field event and then noted on a daily basis whether there were any changes. The following information will generally need to be recorded, as applicable:

- Daily health and safety meetings:
    - Time conducted,
    - Leader,
    - Attendees, and
    - Summary of content.
- Outline of field activities to be performed that day.
- Arrival and departure times of E & E project personnel.
- Arrival and departure times of non-E & E personnel.
- Record of phone calls and/or other contacts (e.g., meetings, conversations, written or electronic communications) with individuals at the site, including names and affiliations.
- A site sketch identifying the site layout, features, and points of interest (with global positioning system [GPS] coordinates, as appropriate). A north arrow and rough scale should be included.
- Physical description of the site (expand on site sketch as necessary to provide a clear "picture" of the site).
- Pertinent field observations and reconnaissance methodology used to gather observations.
- Brief description of oversight procedures. Oversight activities may include:
    - Contractor activities, including operating times,
    - Contractor progress,
    - Contractor deviations from governing documents, and
    - General housekeeping and safety.
- Weather conditions, updated as necessary on successive pages if weather conditions change throughout the field day.
- Documentation of photographs, including:
    - Make and model of the camera,

   - Description of the photograph (noting specific items of interest), including the date and time,
   - Photograph number,
   - Direction or view angle of the photograph, and
   - Name of the photographer.
- Description of monitoring procedures and results.
- Information on monitoring equipment used (e.g., GPS, air monitoring, field screening):
   - Model and serial numbers,
   - Equipment preparation/calibration procedures, date and time, and results if not recorded on separate form, and
   - Field maintenance and/or repairs.
- Description of biological survey conducted (e.g., species survey, wetland survey) and results.
- Sample collection procedures and reference to applicable work plan section or SOP:
   - A sketch of individual sampling locations if no GPS coordinates are available.
   - Pre-sampling activities, such as:
      - Groundwater well purging and the number of volumes purged before sample collection, and
      - Associated data and results (e.g., well purging pH, conductivity, temperature data).
   - Sample information and observations:
      - Sample number, station location ID, programmatic ID, and/or location, including relationship to permanent reference points,
      - Names of samplers,
      - Sample description, sample depth interval, sample time, sample date, and any field screening results,
      - Sample matrix and number of aliquots if the sample is a composite,
      - Soil/sediment characteristics (e.g., grain size, plasticity, color, cohesiveness, moisture content),
      - Water quality parameters (e.g., pH, temperature, conductivity, turbidity) and water characteristics (e.g., color and odor),
      - Characteristics of biological specimens,
      - Container and preservatives used, recipient laboratory including contact information, and requested analyses, and
      - Any preservative added in the field including preservative type, lot number, and expiration date.
   - Quality assurance (QA)/quality control(QC) samples:
      - For trip blanks, indicate the source of the blanks,

    - For equipment rinsate samples, note the equipment from which the rinsate sample is collected and the source of the deioinized (DI) water, and
    - Field duplicates or replicates and a description of how the duplicate was sub-sampled.
  - Equipment and personnel decontamination procedures.
  - Shipping paper (airbill) numbers and chain-of-custody form numbers.

6.4 Work Plan Changes/Deviation

Deviation from the work plan, sampling and analysis plan, quality assurance project plan, health and safety plan, or other project or program plans should be documented, together with authorization for any deviations. Deviations (who, what, where, when, why, and how [the rationale for the change]) from the plans and the circumstances necessitating such changes should be recorded. No work plan changes or deviations may be acted upon without documented authorization from the PM.

6.5 Investigation-Derived Waste

Disposition of non-hazardous versus potentially hazardous investigation-derived waste (IDW) should be delineated in the field planning documents. The following information should be included in the logbook:

- Nature and disposition of non-hazardous wastes;
- The type and number of containers of potentially hazardous IDW generated (each drum or container should be numbered and its contents noted);
- Information relevant to characterizing IDW;
- Disposition of IDW (left on site or removed from site);
- IDW sample information should be recorded the same as other samples; and
- The type of paperwork that accompanied the waste/sample shipment (e.g., manifest).

6.6 Data Collection Forms

Certain phases of fieldwork may require the use of separate project-specific data collection forms, such as sample collection, equipment calibration, wetland survey, or daily summary forms. Use of such forms and the types of information recorded should be noted in the logbook. Information recorded on data entry forms does not need to be repeated in the logbook, but can be summarized and should be appropriately referenced for easy access.

7 Quality Assurance/Quality Control

As discussed in this SOP, important QA/QC measures for maintaining field activity logbooks include the following:

- Logbook entries should be made in real time (and not retroactively) and using indelible ink;
- On a daily basis, the individual responsible for documenting field activities should briefly summarize in the logbook the field activities that are planned to be conducted;

- Key daily activities should be recorded in the logbook;
- Logbook pages should be signed and dated as they are completed;
- Deviation from the work plan, sampling and analysis plan, quality assurance project plan, or other project or program plans should be documented, together with authorization for such deviations;
- The field team leader should review logbook entries on a daily basis, or more frequently if appropriate. The PM should review the logbook on a weekly basis and at the close of fieldwork; and
- Logbooks may be audited by quality assurance personnel from E & E or a client.

8 Special Project Requirements

Project-specific requirements will be included with the project planning documents.

9 References

United States Environmental Protection Agency (EPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* Interim Final. EPA/540/G-89/004, October 1988.

__________. 1991. *Guidance on Oversight of Potentially Responsible Party Remedial Investigations and Feasibility Studies.* Final. EPA/540/G-91/010a.

__________. 1991. *Guidance for Performing Preliminary Assessments Under CERCLA*. EPA/540/G-91/013. September 1991.

__________. 1991. *NEIC Policies and Procedures Manual.* EPA 330/9-78-001-R. May 1978, revised August 1991.

__________. 1992. *Guidance for Performing Site Inspections Under CERCLA.* Interim Final. EPA/540-R-92-021. September 1992.

END OF SOP

Chapter E

E

Supplemental Sample Documentation Forms

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10

CUSTODY SEAL

Date:
Signature:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10

EPA

USEPA Contract Laboratory Program
Inorganic Traffic Report & Chain of Custody Record

1. Case No.:	R
DAS No.:	

2. Region:	3. Date Shipped:	4. Chain of Custody Record	Sampler Signature:
Project Code:	Carrier Name:	Relinquished By: (Date/Time)	Received By: (Date/Time)
Account Code:	Airbill:	1)	
CERCLIS ID:	Shipped To:	2)	
Spill ID:		3)	
Site Name/State:		4)	
Project Leader:			
Action:			
Sampling Co.:			

5. INORGANIC SAMPLE No.	6. MATRIX/ SAMPLER	7. TYPE	8. ANALYSIS/ TURNAROUND	9. TAG No./ PRESERVATIVE/Bottles	10. STATION LOCATION	11. SAMPLE COLLECT DATE/TIME	12. ORGANIC SAMPLE No.	13. QC Type

14. Shipment for Case Complete?	15. Sample(s) to be used for laboratory QC:	16. Additional Sampler Signature(s):	17. Chain of Custody Seal Number:
18. Analysis Key:	**Type:** Comp, Grab (from Box 7)		19. Shipment Iced? ______

20. TR Number:

PR provides preliminary results. Requests for preliminary results will increase analytical costs.

Send Copy to: Sample Management Office, 2000 Edmund Halley Dr., Reston, VA 20191-3400 Phone 703/264-9348 Fax 703/264-9222

REGION COPY

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USEPA Contract Laboratory Program
Organic Traffic Report & Chain of Custody Record

1. Case No.:
DAS No.:

R

2. Region:	3. Date Shipped:	4. Chain of Custody Record	Sampler Signature:
Project Code:	Carrier Name:	Relinquished By: (Date/Time)	Received By: (Date/Time)
Account Code:	Airbill:	1)	
CERCLIS ID:	Shipped To:	2)	
Spill ID:		3)	
Site Name/State:		4)	
Project Leader:			
Action:			
Sampling Co.:			

5. ORGANIC SAMPLE No.	6. MATRIX/ SAMPLER	7. TYPE	8. ANALYSIS/ TURNAROUND	9. TAG No./ PRESERVATIVE/Bottles	10. STATION LOCATION	11. SAMPLE COLLECT DATE/TIME	12. INORGANIC SAMPLE No.	13. QC Type

14. Shipment for Case Complete?	15. Sample(s) to be used for laboratory QC:	16. Additional Sampler Signature(s):	17. Chain of Custody Seal Number:
18. Analysis Key:	Type: Comp, Grab (from Box 7)		19. Shipment Iced? ______

20. TR Number:

PR provides preliminary results. Requests for preliminary results will increase analytical costs.
Send Copy to: Sample Management Office, 2000 Edmund Halley Dr., Reston, VA 20191-3400 Phone 703/264-9348 Fax 703/264-9222

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Chapter F

F Data Management Plan

	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION 10 1200 Sixth Avenue Seattle, Washington 98101 OFFICE OF ENVIRONMENTAL CLEANUP	**Site-Specific Data Management Plan**			
		Project Name:	Gunshy Manor	**TDD Number/Site ID:**	T27-009
		Author:	Linda Ader	**Company:**	Ecology & Environment, Inc.
		Date Initiated:	September 25, 2019	**Last Updated:**	Click here to enter a date.

This data management plan (DMP) is intended to provide guidance for data collection by field personnel and subsequent data management activities. This project DMP is in addition to requirements contained in the EPA Region 10 DMP, or in clarification of (where options exist) the R10 DMP (6/2014). The data collection and management practices presented in this plan are designed to ensure data integrity and consistency for all data collection personnel and from operational period to the next. Listed in this DMP are data elements, data collection equipment, and data management processes, and end-use products. Electronic tools and files used at the site may include GPS data, EDD files for laboratory results, an field analytical database (XRF, Lumex, PID/FID, etc.), field monitoring equipment data (such as water quality data and water levels), a Scribe database to manage all field data and analytical results, and ArcGIS to manage geospatial data.

Data Processing

The following table outlines the specific requirements for various data types being collected during the project.

Data Source	Required Information	Processing Instructions	Processing Frequency	Processing Responsibility	Storage Location	Final Output [format]
Site Documents	Report References, SQAP, logbook	File hard copies and electronic copies in indicated storage location	Beginning of project, and as needed	Project Manager	**Digital:** Personal Laptop **Hard Copy:** Site Doc Box	Site file deliverable
Scribe	Scribe .mdb	1)Publish to scribe.net 2)Provide final .bac file to RSCC	1)Daily or as needed 2)With submission of GIS deliverables/report.	Project Manager	\project file\Scribe	scribe.net **Project ID:**TBD Scribe .mdb file
Fixed Laboratory Analysis	Location ID, sample number, sample date, sample time, analyte, result, qualifier, unit, MDL	Electronic data will be imported into Scribe	Upon receipt of validated data	Project Manager, START chemist	Data: Scribe Raw: \03 Analytical & QA\Laboratory Data	Tabular reports [.xls], Data Memoranda [.pdf]
Field Monitoring Data	Water quality parameters	Electronic data will be imported into Scribe	Within 2 weeks after the conclusion of field event	Project Manager	Scribe	Tabular reports [.xls]
Sample Information	Sample No, Date, Time, Sampler, Location	Record into Scribe as required	As Samples are added	Project Manager	Scribe	Chain-of-Custody forms, labels, tabular reports, and/or maps
GPS	Location, latitude, longitude	Data will be processed according to the GPS Data Processing SOP and uploaded into Scribe	Within 2 weeks after the conclusion of field work	Project Manager and GIS Analyst	Data: Scribe Raw: \02 Execution\GIS	Tabular reports [.xls] and/or maps [.pdf]
GIS	Sample Location Maps	Store in Site Files	Daily or as needed	Project Manager and GIS Analyst	02 Execution\GIS	GIS files Maps [.pdf]
Digital Photos	Camera ID, Time, Direction, Description, Photographer	Store in Site Files	Daily	Project Manager	\02 Execution\Photos	Photo Log [.pdf]

All electronic files will be written to a CD-ROM or DVD and provided to the EPA Task Monitor. All data related files (analytical, monitoring, GPS, GIS, etc.) will also be written to a CD-ROM or DVD and provided to the EPA RSCC. Hard copy files will be assembled and provided to the Task Monitor. Hard copy files will include, but are not limited to logbooks, field forms, lab bottle certificates, waybills, IDW manifests, and geologic logs.